Final Report:
Cobalt-Coleman Mining Camp
Soil Assessment

August 2011

Ontario

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Soil Assessment

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Prepared by:

Ontario Ministry of the Environment

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Editor's Note

The Ontario Ministry of the Environment's technical memorandum summarizing the results of the Cobalt Coleman Mining Camp soil assessment was completed in May 2010. A copy of the memorandum was shared with the Timiskaming Health Unit in the fall of 2010 who hired a toxicological expert to review the findings of the ministry's soil assessment. The results of the expert's review were received by the Ontario Ministry of the Environment in March 2011. This final public report on the ministry's Cobalt Coleman Mining Camp soil assessment addresses comments received by the ministry and has been amended to remove personal information associated with the sampling of residential properties and includes some editorial changes.

Revisions to the Ontario Ministry of the Environment's soil standards found under Ontario Regulation 153/04 came into effect on July 1, 2011 following extensive consultation with various stakeholders. To assist the reader with understanding the results, a table is provided below that summarises O. Reg. 153/04 soil standards before and after the regulatory changes that took effect in July 2011.

This report is based on environmental sampling conducted between 2003 and 2008 and the data are compared to soil standards that were current and in effect at that time. Therefore, some of the information in the report's many data summary tables may not reflect the current soil standards. For example, most tables in this memo identify the number of samples sites that exceeded the Table 1 background or the Table 2 effects-based standards — the number of exceedances would change if interpreted using the current 2011 soil standards.

The actual soil chemical concentrations reported for each and every sample site remain unchanged. Only the threshold to which they are compared may be different. This does not affect the utility of the report to interpret the environmental quality in and around the study area.

Summary of *Ontario Regulation 153/04 -- Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act,* Tables 1 and 2.

Changes to Provincial Soil Standards

Contaminant	**July 1, 2011 Background Soil Standard * (Table 1) (ug/g)**	**2004 to June 30th, 2011 Background Soil Standard * (Table 1) (ug/g)**	**July 1, 2011 Generic Effects-based Standard ** (Table 2) (ug/g)**	**2004 to June 30th, 2011 Generic Effects-based Standard ** (Table 2) (ug/g)**
Antimony	1.3	1.0	7.5	13
Arsenic	18	17	18	20
Barium	220	210	390	750
Beryllium	2.5	1.2	4	1.2
Cadmium	1.2	1.0	1.2	12
Chromium ***	70	71	160	750
Cobalt	21	21	22	40
Copper	92	85	140	225
Lead	120	120	120	200
Mercury	0.27	0.23	0.27	10
Molybdenum	2	2.5	6.9	40
Nickel	82	43	100	150
Silver	0.5	0.42	20	20
Vanadium	86	91	86	200
Zinc	290	160	340	600

** Ontario's Full Depth Background Site Condition Standards for Residential, Parkland, Institutional, Industrial, Commercial, and Community Property use ("background")*

*** Full Depth Generic Site Condition Standards in a Potable Ground Water Condition for Residential, Parkland, and Institutional Property Use ("effects-based soil standard") – Coarse Textured Soils*

**** Total Chromium*

Executive Summary

The Town of Cobalt was founded in 1903 when silver was discovered along the shores of Cobalt Lake. At its peak, the Cobalt-Coleman Mining Camp was home to 20,000 people and over 100 mines and refineries. Between 1903 and 1914, over 227 million ounces of silver was extracted from the Cobalt area, making Ontario the third largest silver producer in the world at the time. Milling and refining operations peaked between 1907 and the mid-1920s. In 2001, the Canadian government declared the Town of Cobalt and the surrounding area a National Historic Site. The Cobalt Historical Society has developed tourist attractions, such as the Heritage Silver Trail, based on the mining and milling history of the area.

Between 2003 and 2008, the Ontario Ministry of the Environment conducted a comprehensive inventory of soil metal levels in and around the Town of Cobalt and Coleman Township. The Ministry's initial efforts focused on locations that were anticipated to be most contaminated by the historical mining activities, such as former mines, mills, and tailings areas. Areas expected to be less impacted, such as schools, public green spaces and residential properties located near tailings areas were sampled in later years. Over this period 1,956 soil samples were collected from 640 locations.

Samples were analyzed for elements that were known or suspected to be associated with the historic mining activities including aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, lead, iron, magnesium, manganese, mercury, molybdenum, nickel, silver, strontium, vanadium, and zinc. The results were compared to *Ontario Regulation 153/04 -- Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (O. Reg. 153/04)* soil standards. Data analysis was limited to basic descriptive statistics (e.g., mean, percentiles, etc) and measurements of correlation. The bio-accessibility of arsenic, cadmium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, and zinc in soil was also assessed at four sites to assist with the understanding of potential human health and ecological impacts.

Arsenic is the major element of concern in the Cobalt-Coleman Mining Camp. Although concentrations of other elements such as antimony, cobalt, copper, lead, mercury, nickel, silver, and zinc are also high, in most cases arsenic concentrations outweigh the possible affects of these other elements. The concentrations of arsenic found in the waste rock fines material, mill waste, and tailings are high enough to pose a possible risk to human health.

Substantially elevated soil metal levels were found in the former mines, mills, and tailings areas due to the presence of mining and milling wastes at these sites. The majority of these sites had metal concentrations that were above the *O. Reg. 153/04* soil standards, in some cases almost 10,000 times the standards. Arsenic was consistently elevated, exceeding the standard at more than 90% of the sample sites with a median concentration across all sample sites of 2,300 micrograms per gram (ug/g) and a maximum of 180,000 ug/g. Other elements including antimony, cobalt, copper, lead, mercury, nickel, silver, and zinc exceeded the provincial soil standards, some by substantial margins.

Select residential properties in Cobalt were chosen for sampling based on their proximity to known mills or tailings areas (i.e., Buffalo Mill, Nipissing Low Grade tailings, Cobalt Reduction Mill, Mile 104 Mill, and Hudson Bay tailings). These properties do not reflect the majority of

residences in Cobalt that are situated away from areas of known historic mining and milling activity. Soil metal levels were substantially lower at these residential properties than at the mine, mill, and tailings areas, although exceedances of the provincial soil standards were common and at some sites quite substantial. Median soil arsenic levels were 140 ug/g and maximum concentrations ranged up to 4,600 ug/g. Lead levels were also elevated, ranging up to 760 ug/g. Other elements exceeding the province's effects-based standards included antimony, cobalt, copper, mercury, nickel, silver, and zinc. For the most part, samples reporting higher soil metal levels were collected from sites closest to the tailings areas.

Generally, the schools and green spaces were found to have the lowest soil metal levels. The lower levels reflect historic action taken to reduce exposure to contaminated residue. Soil has been brought into the school grounds or green spaces to cover areas known or suspected to be associated with historic mine use or tailings. However, soil arsenic standards were exceeded at three of the five sites sampled at the Cobalt-Coleman Public School (maximum level 100 ug/g) and at several sites located in public green spaces sampled around Cobalt (maximum ranged up to 3,100 ug/g). Soil lead levels were not elevated at any of the sites sampled at both schools, but ranged up to 700 ug/g at the green space located near the Pig Town historical site. Other elements exceeding the province's effects based soil standards at public green spaces included antimony, cobalt, copper, nickel and silver.

This technical memorandum provides a comprehensive inventory of soil metals levels in the vicinity of former mines, mills, and tailings areas in the Cobalt Coleman Mining Camp and surrounding area that will be useful for future studies of the area.

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1. Introduction

The Town of Cobalt and Coleman Township are located in north-eastern Ontario, approximately 140 kilometres north of North Bay, Ontario. Cobalt was founded in 1903 when silver was discovered along the shores of Long Lake, now Cobalt Lake. At its peak, the Cobalt-Coleman Mining Camp was home to 20,000 people and over 100 mines (Town of Cobalt, 2002). Between 1903 and 1914, over 227 million ounces of silver was extracted from the Cobalt area, making Ontario the third largest silver producer in the world at the time (Anderson, 1993). Milling and refining operations peaked between 1907 and the mid-1920s and declined through the remainder of the twentieth century due to low silver prices and low ore grade (Anderson, 1993). Twelve hundred people currently live in the Town of Cobalt and five hundred and eighty people live in Coleman Township.

In 2001, the Canadian government declared the Town of Cobalt and the surrounding area a National Historic Site (Appendix A - Map A1). The Cobalt Historical Society has developed a number of tourist attractions based on the extensive mining and milling history of the area. These attractions include three walking tours through the Town of Cobalt and a driving tour, the Heritage Silver Trail, located in the Town of Cobalt and the adjacent Township of Coleman.

The Heritage Silver Trail consists of 21 signed sites along a 17 kilometre loop (Appendix A, Map A1). The sites include eight mill sites, nine mine sites and four building sites located within the Town of Cobalt and Township of Coleman (Cobalt Historical Society, 2000). The three Town of Cobalt walking tours collectively consist of 28 signed sites including 22 building or community sites, 5 mine sites and 1 mill site (High Grader Communications, undated). Four sites overlap between the three Town of Cobalt walking tours and the Heritage Silver Trail resulting in 45 individual historical sites.

Previous studies conducted in the Cobalt area have investigated the impact of the historical mining and milling operations on the environment (e.g., Boyle and Dass, 1971; Dumaresq, 1993; McIlveen, 1977; McIlveen and Balsillie, 1979; McIlveen and Negusanti, 1985; and, McIlveen, 2001). These studies showed elevated concentrations of metals, metalloids, and mercury at or adjacent to a number of the historical mine and mill sites in the Cobalt-Coleman Mining Camp.

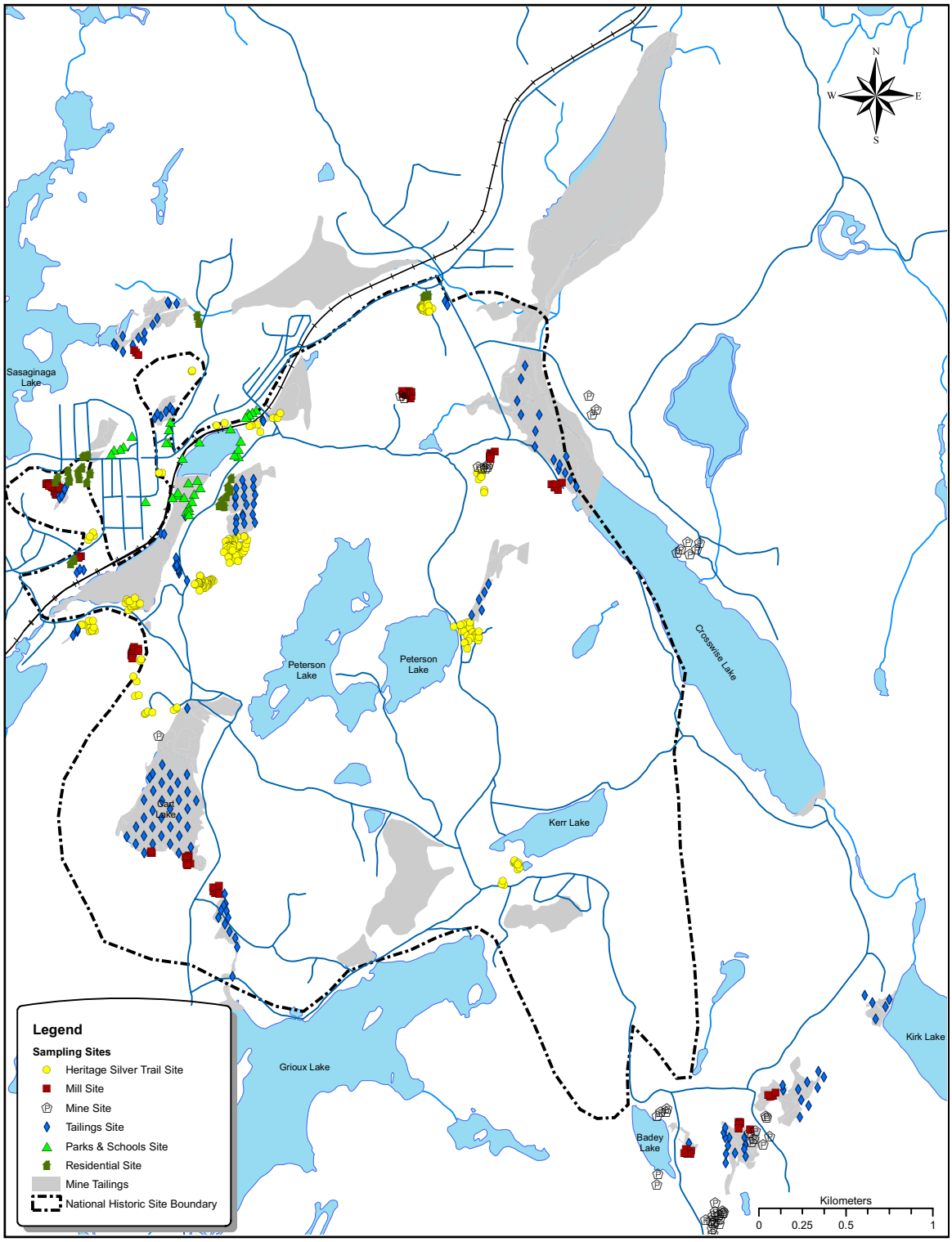
In 2003, the Ontario Ministry of the Environment's Phytotoxicology Investigations Unit initiated a soil assessment program of the forty-five (45) historical tour sites included in the three walking tours and the Heritage Silver Trail (HST) at the request of the Ministry's North Bay District Office. The purpose of the program was to assess the environmental impacts of historical mining activities on the terrestrial ecosystem in the vicinity of the tour sites established in the Cobalt-Coleman Mining Camp. The study was later expanded to include other accessible mine, mill and tailing areas, schools, parks, green spaces and select residential properties adjacent to mill and tailings areas in the Town of Cobalt and Coleman Township. Several accessible mine, mill and tailing areas in parts of Bucke Township were also included in the expanded program.

2. Methods

2.1 Field Activities

Field sampling of soil and soil like material in the Cobalt-Coleman Mining Camp and surrounding areas was conducted between 2003 and 2008. Over this period 640 sampling stations were established at fifty eight discreet locations and 1956 soil samples were collected and submitted for analysis (Table 2.1). Twenty mill sites, fourteen tailings areas, and fifteen mine sites were sampled as part of the Ministry's soil assessment program. Two schools, three

residential areas adjacent to mill and tailings areas, and several green spaces (i.e., parks, playgrounds) were also sampled as part of the program. Sampling locations in the Cobalt-Coleman Mining Camp and surrounding area are highlighted in Map 2.1 below.



Map 2.1: 2003 to 2007 MOE Sampling Sites – Main Mining Camp

In October 2003, the Nipissing High Grade Mill was completely sampled and the Nipissing Low Grade Mill (HST Site 7), the McKinley Darragh Mill (HST Site 3), and the Buffalo Tailings were partially sampled.

In 2004, sampling activities concentrated on Heritage Silver Trail sites. Between August 17 to September 23, 2004, the following sites were sampled: the Townsite Headframe and the Glory Hole (HST Site 1 and 2), the McKinley Darragh Mill (HST Site 3), the Little Silver Vein and adjacent Nipissing Reduction Mill (HST Site 4), the Cart Lake Lookout (HST Site 5), the Nipissing No. 96 Mine (HST Site 6), the Nipissing Low Grade Mill (HST Site 7), the Right-of-Way Mine and adjacent Mill Creek (HST Site 9), the Agnico Eagle Refinery & LaRose Blacksmith Shop (HST Site 10 & 11), the Nipissing Shaft No. 73 (HST Site 12), the Mile 104 Mill (HST Site 15), the Colonial Mine and adjacent Colonial Mill (HST Site 16), the Nova Scotia Mill (HST Site 17), the Crown Reserve Mine (HST Site 18), and the Silver Sidewalk (HST Site 19).

In 2005, sampling activities concentrated on the publicly accessible mines, mills and tailings in the Cobalt-Coleman Mining Camp that were not part of the Heritage Silver Trail. Between June 14 to September 30, 2005 the following locations were sampled: Crosswise Lake Tailings, Silver Cliff Mill, Trethway Mill and Tailings, Hudson Bay Tailings, Cart Lake Tailings, Cobalt Provincial Mill, Silver Summit Mill, Mensilvo Mill and Tailings, Beaver and Temiskaming Mills and Tailings, Silver Miller Mill and Tailings, Bradey Lake Mines, Cobalt Load Mine, Cobalt Lake and the Nipissing Low Grade Tailings.

Sampling activities in 2006 concentrated on the schools, parks and green spaces in the Cobalt-Coleman community and outlying mines, mills, and tailings not sampled in 2005. From June 6 to July 26, 2006 the following locations were sampled: the Cobalt Coleman Public School, the St. Patricks School, the soccer fields, baseball field, playground and green spaces around Cobalt Lake, the Cobalt Refinery on Hwy 11, the Kirk Lake Tailings, the mines on the east side of Crosswise Lake, the Green Meehan Mine, Mill and Tailings, the Helen's Eplet Mine, the Teledyne Professor Mine and Bucke Park. In October 2006, twelve of the sites sampled in 2004 were resampled to replace lost samples.

In 2007, sampling activities consisted solely of the sampling of residential properties immediately adjacent to tailings or mill sites. Eighteen residential properties were sampled including nine properties on or adjacent to the Buffalo Tailings or the High Grade Mill, five properties adjacent to the Nipissing Low Grade Tailings and four other properties spread throughout the Cobalt-Coleman community.

Local control samples were collected from five locations in the Cobalt-Coleman Mining Camp in September 2008.

Table 2.1: Sampling Summary 2003 to 2008

Year	Locations	Sampling Stations	Samples
2003	4	67	174
2004	16	251	582
2005	18	215	810
2006	18	101	265
2007	18	24	95
2008	5	5	30

2.1.1 Field Screening and Site Reconnaissance

Site reconnaissance was conducted at each historical site sampled prior to sampling. Ministry scientists and Provincial Officers identified potential areas of concern, designed and implemented a sampling strategy for each site, conducted field screening, and mapped and documented the condition of each historical site. Potential areas of concern were identified based on a review of records and field observations and were incorporated into the sampling strategy for each site. Sampling strategies varied between historical sites, depending on site and logistical constraints, and included sequential sampling on a grid pattern and focussed sampling around potential areas of concern.

Field screening was conducted at each historical site using a field portable x-ray fluorescence (XRF) spectrometer to screen soil metal and metalloid concentrations *in-situ*. A Niton Corporation 700 series XRF was used in 2003 and 2004 and an Innov-X-System Model 440 XRF (Innov-X Systems, Inc.) was used in all subsequent years. The XRF data were used to assist Ministry scientists in selecting representative soil sample locations and to ensure all potential areas of concern were sampled.

All samples and sampling locations were documented, using digital photographs, detailed location maps, geo-coordinates, sampling location observations, and sample observations. In 2003, geo-coordinates were collected using a Garmin 12XL Global Positioning System (GPS) receiver with an accuracy of ±15 metres (m). A Garmin GPS Map 60Cs GPS receiver with an accuracy of ±10m was used in 2004 and 2005 and a Garmin GPS Map 60Csx GPS receiver with an accuracy of ±5m was use in all subsequent years. Appendix D Table D1 provides the coordinates for each sampling location and Figures D1 to D637 provides photographs of each sampling station.

2.1.2 Soil Sampling Methods

Soil samples were collected either as composites of a designated sampling area or as discreet samples. Composite soil sampling was generally used as it increased the coverage and efficiency of the sampling activities. The designated sampling area used in composite sampling ranged in size from one metre to ten metre square areas depending on the results of XRF field screening and soil texture analysis. The size of a designated sampling area was determined when the XRF field screening and soil texture results were consistent over the entire sampling area. This procedure ensured that the cores of each composite sample were similar and representative of the designated sampling area. The size of each designated sampling area was recorded for each composite sampling location. Discrete samples were collected from locations where XRF field screening and/or soil texture indicated unique results within a small spatial area (i.e., less than one metre square).

In 2003 and 2004, soil sampling was completed using a hand-held, stainless steel soil corer (core length 0.3 metres to 0.45 metres), a stainless steel trowel, or a manual slide hammer combined with a stainless steel corer (core length 0.3 to 0.45 metres). In all subsequent years an Eijkelkamp gouge auger (core length 1.0 metre) was used for core sampling. Composite soil samples comprised of ten soil aliquots (or cores) taken from a grid or "X" pattern that was applied to a designated sampling area representative of the sampling location were collected using the hand-held soil corer or trowel. Each soil core was divided into five or ten centimetre (cm) increments where depth samples were possible and the cores of each depth interval (e.g., 0 - 5 cm, 5 – 10 cm, etc) were placed in a labelled, food-grade polyethylene bag. The ten or more core sections per bag per designated sampling area are referred to as a composite soil sample. A duplicate soil sample was collected at a site by performing the soil sampling procedure a second

time across the same designated sampling area. A trowel was generally used when the presence of gravel or building debris made sampling with a hand-held soil core impracticable. For discrete soil samples, a hand-held soil corer, trowel, or manual slide hammer was utilized to collect a soil sample from one sampling location to a maximum depth of 40 centimetres below surface grade. Where depth samples could be collected, each soil core was divided into five or ten centimetre increments and each depth interval (e.g., 0 - 5 cm, 0 – 10 cm, etc) was placed in a labelled, food-grade polyethylene bag.

All sampling equipment was decontaminated between sampling locations following MOE standard protocols (MOE, 1993 and MOE, in progress). Soil texture, colour and moisture were determined in the field for each sampling location using standard soil methods (Denholm and Schut, 2003). All samples and sampling locations were documented and digital photographs taken. All sampling was conducted according to standard MOE sampling protocols (MOE, 1993 and MOE, in progress).

2.2 Laboratory Methods

2.2.1 Sample Processing

All soil samples were delivered to the MOE's Phytotoxicology Laboratory in Toronto for sample processing. Sample processing involved the following steps:

a. pre-screening with an XRF to determine the approximate concentration of arsenic, cobalt, copper, lead, nickel, and mercury.
b. fresh weights measured and recorded.
c. air drying.
d. dry weight measured and recorded.
e. sieving with 2 mm sieve, recording the weight of both resulting fractions (> 2mm and 2 mm), recording the composition of the > 2 mm fraction and then discarding the > 2mm fraction.
f. taking a sub sample of the 2 mm sample and sieving and grinding until all of the sub sample passed through a 355µ sieve.
g. taking a sub sample of the 2mm sample, sieving with 250µ sieve and recording the weight of both resulting fractions.

XRF screening was completed using either a Niton Corporation 700 series XRF analyzer or an Innov-X Systems XT-440 series XRF spectrometer. Sample weighing was completed using a Mettler PC400 scale while sample sieving was conducted using standard American Society for Testing and Materials stainless steel sieves.

Sample processing steps c, e and f were completed following MOE standard operating procedures (MOE, 2000). The 250µ sieving step is not a standard MOE sample processing procedure. The United States Environmental Protection Agency (EPA) and other researchers have determined that the 250µ fraction of soil is the fraction that will readily adhere to skin and may subsequently be ingested (EPA, 2000; Kissel et. al., 1996; and, Duggan, 1983). The EPA considers this soil size fraction to be the primary source of ingested soil and dust (EPA, 2000). It was therefore decided that chemical analysis should be performed on both the 2 mm and the 250µ soil fractions to determine element concentrations in the readily ingested soil fraction versus the 2mm soil fraction. All samples collected in 2003 and 45% of the samples collected in 2004 (selected at random) were processed for both 355µ and 250µ. None of the 2005, 2006 or 2007 samples were processed for 250µ.

In 2003, 2006, and 2007, the sample processing steps a to g were conducted by the MOE's

Phytotoxicology Laboratory. In 2004 and 2005, sample processing steps a and g were completed by the MOE's Phytotoxicology Laboratory while sample processing steps b to f were conducted under contract by Agat Laboratories, Mississauga, Ontario.

In addition to the above noted sample processing procedures, the MOE's Phytotoxicology Laboratory analyzed all soil samples for pH and electrical conductivity (EC) in accordance with standard MOE methods (MOE, Draft a; and, MOE, Draft b).

2.2.3 Laboratory Analysis

In 2003, all processed samples (both the 2mm and 250µ soil fractions) were submitted to the Ministry's Laboratory Services Branch (LaSB) in Toronto for analysis of aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), calcium (Ca), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), iron (Fe), magnesium (Mg), manganese (Mn), mercury (Hg), molybdenum (Mo), nickel (Ni), silver (Ag), strontium (Sr), vanadium (V), and zinc (Zn). One of the duplicate samples from each sampling site was also analyzed for total and free cyanide (CN). Silver (Ag) was analyzed in both duplicates for approximately half the sample locations and in only one duplicate for the remaining sample locations due to laboratory lab load restrictions. Selenium was not recovered during analysis and was not reported due to interference from other elements. Analysis was completed in accordance with LaSB accredited analytical methods including method E3059A for mercury, E3075A for silver, E3015A for total and free cyanide, E3245A for antimony, arsenic and selenium and E3073A for the remaining metals. Analysis for polycyclic-aromatic hydrocarbons (PAHs) was also conducted on a limited number of samples in accordance with LaSB accredited analytical method E3425 (MOE, 2007; MOE, 2008a; MOE, 2008b; MOE, 2008c: MOE, 2008d).

All samples collected between 2004 to 2007 (both the 2mm and 250µ soil fractions) were submitted to the University of Guelph, Soils and Nutrient Laboratory for analysis for Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Pb, Fe, Mg, Mn, Hg, Mo, Ni, Ag, Sr, V, and Zn. Cyanide and PAH analysis were not performed on these samples. Analysis was completed in accordance with the following Soils and Nutrient Laboratory accredited analytical methods: METALS-002 for mercury, SNL-014 for arsenic and antimony, SNL-044 for silver, and SNL-013 for the remaining metals (University of Guelph 2004a, b, c, and d). Each of these methods is based on the corresponding MOE LaSB's method.

The control samples collected in 2008 were submitted to the LaSB in Toronto for analysis of Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Pb, Fe, Mg, Mn, Hg, Mo, Ni, Ag, Sr, V, and Zn.

2.2.4 Bio-accessibility and Speciation Analysis

In addition to the above noted analysis, LaSB determined the bio-accessibility of arsenic, cadmium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, and zinc in the 250µ soil fractions. Bio-accessibility was determined using a modified in vitro bio-accessibility method developed by the Solubility/Bioavailability Research Consortium (SBRC) (SBRC, 2000). The MOE's bio-accessibility method (MOE, In Progress a) was in the development / method acceptance stage and was not accredited at the time of analysis. The SBRC in vitro method measures the fraction of an element solubilized from soil under simulated gastrointestinal conditions. The MOE method only simulates the stomach phase of the gastrointestinal tract. Bio-accessibility analysis was performed to provide additional information on the relative bio-accessibility of these elements in representative soil samples from the Cobalt area. Sixteen samples, eight from the Nipissing High Grade Mill, three from the Nipissing Low Grade Mill, three from the McKinley-Darragh Mill, and two from the Buffalo Mill Tailings were analyzed

for bio-accessibility.

Bio-accessibility refers to the fraction of the total element concentration in a soil material which may become solubilized in a human gastro-intestinal tract (SBRC, 2000). Bio-accessibility values assist scientists in the assessment of the bioavailability of contaminants to human and ecological receptors. "Bioavailability is the fraction of a contaminant … that is absorbed by an organism via a specific exposure route" (SBRC, 2000). The determination of bioavailability often requires detailed animal or *in vivo* studies while the determination of bio-accessibility, an indirect measure of bioavailability, can be completed using laboratory or *in vitro* studies. There is much debate in the scientific literature regarding *in vitro* methods for determining bio-accessibility for metals in soil material (e.g., Rodriguez et al., 1999; Ruby et al., 1993; Ruby et al., 1996; SBRC, 2000; and Williams et al., 1998).

The *in vitro* method used for this project was modified from a method used at United States naval facilities (SBRC, 2000). This method was chosen as it is reproducible, there are good correlations for lead between in vitro results using this method and *in vivo* studies using swine (SBRC, 2000), and because it is based on a widely referenced in-vitro method developed by Ruby et al., 1993. Correlations between *in vitro* results using this method and *in vivo* studies for other elements, however, have not been published.

Nine of the sixteen samples analyzed for bio-accessibility were sent to SGS Lakefield Research Limited of Lakefield, Ontario for metals speciation, arsenic mobility, and extractable and non-extractable mercury analysis. Metals speciation was analyzed using the Tessier sequential extraction method for arsenic, cobalt, copper, nickel, lead, and zinc (Tessier et al., 1979). Arsenic mobility was determined using the method developed by Cai et al., 2002. Mercury extractability was determined by selective solvent extraction (Draft EPA Method #3200).

2.3 Data Analysis

Data analysis was limited to performing a Pearson Correlation analysis and plotting the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver. The correlation of elemental concentrations in soil can be useful in determining the origin of soil material and for remedial applications. Pearson Correlations were performed on the aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, vanadium and zinc results for each site. The Pearson Correlation analysis and relationship plots were completed using Microsoft® Excel 2003.

A simple regression analysis between the two sets of antimony, arsenic, cobalt, copper, lead, mercury, nickel, silver and zinc results for each sampling site was performed for the 2003 and 2004 data (the two years that samples were separated into both < 2mm and $<250\mu$ soil fractions). Regression analysis was only performed for sites where more than four samples had been collected and included both < 2mm and $<250\mu$ soil fractions results.

No spatial analysis or contour maps were produced because of the heterogeneous nature of the results. Instead, dot maps were created for each site to show the spatial distribution of each contaminant. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The dot maps were created using ESRI™ ArcMap 9.1 GIS software. The base map data used were created from scanned and rectified 1989 Ontario Ministry of Natural Resource air photographs (photos 1989-11-111, 1989-11-113, 1989-31-179 and 1989-31-181 respectively).

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver for each sampling location are provided in Appendix A, Maps A5.2 to A37.8. The same concentration range was used for each contaminant at all sites for comparison purposes. Concentration dot maps were not created for the green space and residential sampling sites.

The results of the Pearson Correlation analysis are given in Appendix B, Tables B1 to B46. For discussion purposes, correlations of 0.80 and higher were considered significant and were highlighted in bold font. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Appendix B Figures B1.1 to B46.c.6. The results of the regression analysis between the < 2mm and < 250µ soil fractions are given in Appendix B along with the arsenic relationship graphs.

The results of the bio-accessibility analysis for the nine 2003 soil samples are given in Appendix C, Table C49. The results of the metals speciation using the Tessier method are presented in Table C50. The results of the arsenic availability and extractable mercury for the nine 2003 soil samples are presented in Table C51.

4. Discussion

The discussion of the results has been divided into four sections due to the large study area and diverse nature of the mining and milling activities in the Cobalt-Coleman Mining Camp. The four sections include the Heritage Silver Trail; other publicly accessible mines, mills and tailing sites; schools and parks; and, residential properties. These four sections have been further divided into location specific sub-sections.

Due to the large volume of data the discussion has been limited to summarizing the data, reporting the number of exceedances of *O. Reg. 153-04 Standards*, highlighting those locations where the highest concentrations of analytes were found, and examining the relationship between arsenic and other metals of concern.

4.1 Local Soil Background Concentrations

Throughout this document the results of the chemical analysis are compared to *O. Reg 153-04 Table 1 Background Standards*. These standards were derived from soil sampling conducted by the Ministry throughout Ontario in the early 1990s as part of the Ontario Typical Range program and represent the upper limit of what would typically be expected to be found in soil not impacted by industrial point sources. There has been discussion with members of the Cobalt-Coleman community as to whether these standards are applicable to the Cobalt-Coleman area. It has been suggested that due to the mineralization of the bedrock in the area, the soil background concentrations for a number of elements should actually be higher than the Table 1 Background Standards.

To determine whether or not this is the case, in September of 2008, five sites within the Cobalt-Coleman Mining Camp area were selected as possible control sites and were sampled in duplicate at 0 to 5, 5 to 15, and, 15 to 25 cm intervals. Due to the large extent of mining activity over a great many years, it is very difficult to find areas within the mining camp that have not been affected by the mining activity. The five locations sampled included a site within the forest located on the south side of the road between Kerr Lake and Bradey Lake, a site within the forest located along the Kerr Lake Road east of Kerr Lake, a site within the forest located on the south side of Cross Lake Road, and two sites along the shore of Sassaginaga Lake, an area protected from human activity as the source of drinking water for the community (sites 828, 829, 830, 831, and 832, respectively). At the time of sampling there were no obvious signs of past mining

3. Results

All of the results for sampling conducted in the Cobalt-Coleman Mining Camp between 2003 and 2008 are given in Appendix C. The results have been broken into logical units based on either the sampling site or the land use classification f or discussion purposes. Two tables have been created for each logical unit. The first table (Table C1.a) includes all of the results for analytes for which there are *Ontario Regulation 153-04 – Records of Site Condition* soil standards (e.g., antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, vanadium and zinc). The results are expressed in µg/g dry weight.

Throughout this report, the results of the soil chemical analysis are compared to the *MOE's Soil, Ground Water and Sediment Standards for Use Under Part X.V.1 of the Environmental Protection Act* (Province of Ontario, 2004a) background-based (Table 1) and generic effects-based (Table 2) soil standards. These soil standards are part of *Ontario Regulation 153/04 – Records of Site Condition – Part XV.1 of the Act* (Province of Ontario, 2004) which came into force on October 1, 2004. This regulation and its accompanying technical documents replaced the MOE's Guideline for Use at Contaminated Sites in Ontario (MOE, 1997).

Background-based soil standards represent the upper range of background chemical concentrations in soil in the Province of Ontario. An exceedance of the background standard indicates the likely presence of a contaminant source. The generic effects-based soil standards have been established to protect against the potential for adverse effects to human health, ecological health, and the natural environment, whichever is the most sensitive receptor. An exceedance of the generic effects-based standard indicates the potential for an adverse effect to the most sensitive receptor. See Appendix E for a description of the *Ont. Reg. 153/04* standards and how these standards should be interpreted.

The background "All Other Types of Property Uses" and the generic "Residential/Parkland/Institutional Property Use, Medium and Fine Textured Soil" soil standards have been applied in this report. The mill, mine and tailing areas sampled between 2003 and 2007 are former industrial properties. However, since these properties are now used primarily for recreational and educational use, the Residential/Parkland/Institutional Property Use standards apply. The coarse textured soil standards were applied in assessing the results as this was the predominant soil texture encountered during the sampling program. Analytical results that exceeded the background standards have been highlighted using bold text and results that exceeded the generic standards have been highlighted using bold and underlined text. It should be noted that the soil standards only apply to the 2mm soil fraction and that there are no provincial soil standards specific to 250µ soil fractions.

The second table created for each logical unit (Table C1.b) includes all analytes for which there are no *Ont. Reg. 153-04 – Records of Site Condition* soil standards (e.g., aluminum, calcium, iron, magnesium, manganese, and strontium). These results are compared to the Ontario Typical Range (OTR_{98}) guidelines that represent the expected range of concentrations of chemical parameters in surface soil from areas in Ontario not subjected to the influence of known point sources of pollution. Results for these analytes exceeding the OTR_{98} guidelines have been highlighted in bold font. These analytical results are also expressed in µg/g dry weight. The second table also includes the date the sample was collected, the type of material making up the bulk of each sample (i.e., soil, parking lot gravel, tailings, mill waste and waste rock fines), sample pH, sample Electrical Conductivity (EC) expressed in µS/cm, and soil texture sieve results. Soil texture sieve analysis was limited to the 2 mm and 250µ sieves resulting in three

soil texture classes: > 2mm (gravel and non-soil material), between 2 mm and 250µ (coarse and medium sand) and < 250µ (fine sand, silt and clay).

A sub-sample of the samples sent to the University of Guelph lab for analysis were also submitted to the MOE's Laboratory Services Branch (LaSB) for quality assurance testing. A total of 189 samples collected between 2004 and 2007 were analyzed by both labs. Regression analysis was performed on the analytical results produced by the two labs. The results of the regression analysis are given in Table 3.0.

Table 3.0: Comparison of Laboratory Services Branch and University of Guelph Results for 189 samples

Element		Slope	R^2	Element		Slope	R^2
Antimony	**Sb**	0.67	0.52	**Selenium**	**Se**	*1.14*	*-1.18*
Arsenic	**As**	0.94	0.93	**Silver**	**Ag**	0.98	0.97
Barium	**Ba**	0.76	0.96	**Vanadium**	**V**	0.88	0.76
Beryllium	**Be**	*0.47*	*-0.51*	**Zinc**	**Zn**	0.96	0.99
Cadmium	**Cd**	0.58	0.72				
Chromium	**Cr**	0.89	0.83	**Non *O. Reg 153-04* Elements**			
Cobalt	**Co**	0.94	0.99	**Aluminum**	**Al**	0.97	0.81
Copper	**Cu**	1.03	0.99	**Calcium**	**Ca**	0.99	0.99
Lead	**Pb**	1.13	0.98	**Iron**	**Fe**	0.84	0.83
Mercury	**Hg**	1.10	0.99	**Magnesium**	**Mg**	0.91	0.75
Molybdenum	**Mo**	0.75	0.90	**Manganese**	**Mn**	0.84	0.91
Nickel	**Ni**	0.88	0.99	**Strontium**	**Sr**	1.07	0.99

- slope and R^2 are the results of regression analysis using MS Excel®

There was good agreement between the two laboratories for aluminium, arsenic, calcium, chromium, cobalt, copper, lead, mercury, magnesium, manganese, nickel, silver, strontium, vanadium, and zinc with the University of Guelph's results tending to be lower but within acceptable limits of the LaSB results. There was a good relationship between the two labs for barium and molybdenum however the Guelph lab results were only 75% of the LaSB results. As these two elements were found only in low concentrations in the Cobalt-Coleman Mining Camp, this difference is not of concern. There was poor agreement for cadmium and no agreement between the two labs for beryllium and selenium. This lack of agreement is partially due to the low concentrations of these elements with most of the results falling below or just above the method detection limits. Again, as these elements were found in low concentrations in the Cobalt-Coleman Mining Camp, these differences are not of concern.

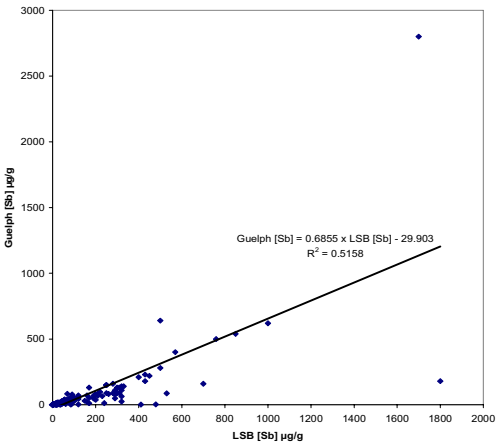


Figure 3.0: Guelph vs. LSB antimony results

The antimony results obtained from the Guelph laboratory were only 68% of the results produced by LaSB and there was significant scatter at the higher concentrations (Figure 3.0). As the concentrations of antimony in the Cobalt-Coleman Mining Camp were regularly well above the *O. Reg. Table 2 Standard* of 13 µg/g, caution must be used in interpreting the antimony results. The samples sent to the Guelph lab were not re-analyzed for antimony as this would have delayed the reporting of the remaining results by up to a year. Archived samples can be re-analysed for antimony at a future date if warranted.

activities at these sites and screening with the portable XRF instrument indicated concentrations of arsenic below 30 ppm.

The results of the analysis of these samples are given in Appendix C, Tables 1.a and 1.b. Graphs of the concentration depth profiles for aluminum, antimony, arsenic, cobalt, copper, iron, lead, mercury, silver, strontium, vanadium and zinc are presented in Appendix B, Figures 49.a to 49.l.

Soil depth intervals were collected at the five control sites as a concentration profile with depth can provide an indication as to whether or not the site has been impacted by mining activities. In undisturbed soils, with the exception of some leaching of iron, aluminum and calcium that occurs during natural soil processes, the majority of the analytes should have the same concentration at all three depths. In soils impacted by mining activities, analyte concentrations will be highest at the surface and will decrease with depth.

The profiles for strontium and vanadium at all five control locations showed no significant increase with depth. This would be expected as these elements are not found in elevated concentrations in the ore from this area. Aluminum and iron had either the same pattern or increased slightly in concentration with depth as would be expected with natural leaching. Sampling sites 828 and 829 showed distinct patterns of decreasing concentration with increasing depth for antimony, arsenic, cobalt, lead, silver and zinc indicating that these sites had been impacted by mining activities. Sampling site 830 showed a similar pattern however the rate of decrease with depth and the actual concentrations were less that at sites 828 and 829. Sampling sites 831 and 832 along the shores of Sassaginaga Lake had essentially the same concentrations at all three depths and generally had the lowest concentrations for these elements. These results indicate that the two sampling sites along the shores of Sassaginaga Lake best represent the local background concentrations for the Cobalt-Coleman Mining Camp.

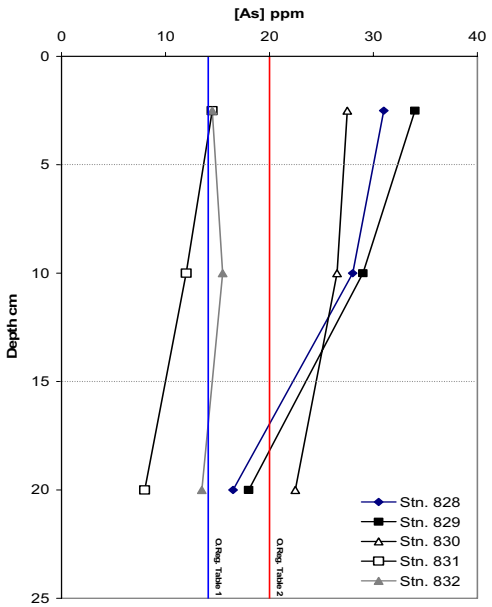


Figure 4.1: Control site arsenic depth profiles

Figure 4.1 compares the concentrations of arsenic at control sites 831 and 832 to the *O. Reg. Table 1 Background Standard* for arsenic. This figure shows that the background concentration for arsenic in the Cobalt-Coleman Mining Camp area is right at or slightly below the Table 1 standard for arsenic of 14 µg/g dry weight. The concentration of arsenic for the 15 to 20 cm depth at the other three control sites also approached the Table 1 standard. The concentrations of antimony, cobalt, copper, lead, mercury, nickel, silver and zinc at the Sassaginaga Lake control sites were all below the Table 1 standards. These results suggest that the high concentrations of various metals in the local bedrock have not resulted in naturally occurring concentrations greater than the Table 1 standards and that using the *O. Reg. Table 1 Background Standards* for comparative purposes in this report is reasonable.

Boyle and Dass (1971) sampled unconsolidated soil material in the Cobalt area to determine average trace element content in areas well removed from sites of known mineralization as well as sites in the vicinity of mineralized veins. Background concentrations in unconsolidated soil

material in areas removed from mineralization for arsenic ranged from <2 to 5 µg/g, antimony 1 to 3 µg/g, cobalt 3 to 19 µg/g, lead 5 to 25 µg/g, mercury 0.11 to 0.5 µg/g, nickel 11 to 54 µg/g, and silver <0.5 to 0.5 µg/g (Boyle and Dass, 1971). Concentrations in unconsolidated soil material, in the vicinity of mineralized veins, was variable but ranged from greater than 2 to greater than 10 times and up to 100 times the recorded background trace element content (Boyle and Dass, 1971).

4.2 Heritage Silver Trail

Heritage Silver Trail (HST) Sites 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19 and 20 were sampled as part of the Ministry's soil assessment program. The Cobalt Lake Mine and the Nipissing High Grade Mill, HST locations that are unnumbered but include posted signs, were also sampled. Each of these locations is discussed individually below. Select mines, mills or tailings that are not officially part of the Heritage Silver Trail but are immediately adjacent to official sites were also sampled and are included in the discussion below.

4.2.1 Heritage Silver Trail Sites 1&2: Townsite Headframe and the Glory Hole

HST Sites 1 and 2 are co-located and accessed through the same parking lot. Site 1 is the Townsite Headframe No. 1 which was built in 1907. Site 2 is an open mining pit referred to as the Glory Hole. Both of these sites are fenced off as physical mine hazards but can be viewed by the public by following a short gravel path from the parking lot to a lookout point located at the edge of the Glory Hole. These sites were sampled on August 19, 2004. Ten samples were collected from five locations (stations 249 to 253; refer to Map A5.1). Duplicate surface soil samples (0 to 5 cm) were collected using a hand trowel at each sampling station.

The results of the chemical analysis of the samples collected from HST Sites 1 and 2 are given in Appendix C, Tables C2.a and C2.b. Table C2.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font while results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C2.b. Results in Table C2.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.1.1 below.

Table 4.2.1.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 1 and 2: Glory Hole and Townsite Headframe

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5200	2.0	7	20	0.1	0.2	5300	19	5	19	7100	7	6000	190	0.04	<0.3	14	<0.2	5	21	17	21
5th	5200	2.0	9	20	0.1	0.2	5300	19	6	20	7400	7	6100	190	0.04	0.4	14	<0.2	5	21	17	21
25th	11000	3	100	24	0.3	0.2	7400	46	35	44	18000	93	6600	300	0.44	0.6	46	<0.2	9	23	41	98
50th	12000	6	180	26	0.3	0.2	11000	49	58	83	20000	120	9200	320	0.48	1.0	62	0.3	12	29	50	100
75th	12000	7	300	91	0.4	0.2	57000	56	84	110	21000	170	10000	440	0.62	1.3	67	0.3	18	42	62	160
95th	14000	44	2000	110	0.8	3	71000	72	690	350	81000	430	13000	600	8.7	3	510	0.5	230	72	67	1100
Maximum	14000	68	2400	120	0.8	4	71000	75	900	420	90000	480	13000	650	11	4	610	0.6	370	73	68	1300
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
OTR_{98} [3]	0	-	-	-	-	-	3	-	-	-	2	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	10	8	0	0	2	ns	1	8	5	ns	4	ns	ns	8	1	8	0	10	ns	0	3
Table 2 [5]	ns	2	8	0	0	0	ns	0	7	2	ns	2	ns	ns	1	0	2	0	2	ns	0	2

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver are presented in Appendix A, Maps A5.2 to A5.8 respectively. The results of the Pearson Correlation analysis are given in Appendix B, Table B1 and the plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel, and silver are given in Figures B1.1 to B1.6 respectively. The results of the regression analysis performed on the < 2mm and < 250µ soil fractions are given in Figures B1.7 to B1.15.

Concentrations of arsenic exceeded the *O.Reg 153-04 Table 2 Generic Standards* at all sampling sites except for the site established in the parking lot. The highest concentrations were found at station 252, a 10 x 10 m area to the south of the gravel trail in the vicinity of the platform that overlooks the Glory Hole (Figure D101). The average concentration of arsenic at station 252 was 2000 µg/g dry weight for the 2 mm soil fraction and 2350 µg/g dry weight for the < 250µ soil fraction. The concentrations of arsenic at the other three sites were significantly lower, ranging from 94 to 310 µg/g dry weight. There was approximately twenty percent more arsenic, copper, lead and mercury found in the < 250µ soil fractions than was found in the < 2mm soil fractions. Concentrations of antimony, cobalt, nickel and zinc were the same in both soil fractions.

The large differences in the concentrations of arsenic and other metals between station 252 and the other four sampling sites resulted in a large number of significant correlations between the elements in the Pearson Correlation analysis. These correlations are mainly driven by the two samples from station 252 and are not considered good correlations. Only cobalt and nickel showed a strong linear relationship with arsenic (see Figures B1.2 and B1.5).

Concentrations of antimony, cobalt, copper, lead, mercury, nickel, silver and zinc exceeded the O.Reg 153-04 Table 2 standards at station 252. Of these metals, only cobalt exceeded the O.Reg 153-04 Table 2 standards at the other three sampling stations.

The results for the gravel samples taken from the parking lot indicated that the gravel was not contaminated with arsenic or any of the other metals tested. The gravel for the parking lot was brought in during the construction of the Heritage Silver Trail site and the results indicate that there has been no migration of contaminants from the surrounding contaminated soil, waste rock or mining debris.

4.2.2 Heritage Silver Trail Site 3: McKinley-Darragh Mill (MDM)

The McKinley-Darragh Mill (HST Site 3), consisting of a large concentrator mill and a tailings mill, is located on the S½ of the N½ of Lot 6, Concession V, Coleman Township at the southeast end of Cobalt Lake. The concentrator was built in 1907 and operated continuously until 1921. It reopened in 1921 and closed again in 1927. A flotation mill was built at the site in 1917 to recover silver from the tailing sands. The flotation mill operated until 1920 and burned down in 1928. Most of the tailings were deposited into Cobalt Lake. Some of the tailings were deposited at the base of the mill and into a small bay of Leaf Lake (the above background information is from Anderson, 1993).

This site was initially sampled on October 24 and 25, 2003 during which time sixteen samples were collected from six locations (sampling stations 198 to 203). Additional sampling was conducted around the top of the mill site on August 26, 2004 at which time ten samples were collected from five locations (stations 362 to 366). On September 23, 2004 sixteen samples were collected from four locations (stations 475 to 478) within the tailings immediately south of the mill in a bay off Leaf Lake (Appendix A, Map A6.1). Sampling in the mill's foundations was limited to 0 to 5 cm depths using a trowel due to the thin layer of soil and the large amounts of

debris in the soil. Tailings at the base of the mill and in the bay were sampled to various depths using a soil corer.

The results of the chemical analysis of the samples collected from HST Site 3 are given in Appendix C, Tables C3.a and C3.b. Table C3.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C3.b. Results in Table C2.2 exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.2.1 below.

Table 4.2.2.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 3: McKinley Darragh Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5100	5	46	5	0.5	0.2	1300	25	17	36	18000	13	2200	290	0.17	0.3	34	0.2	5	9	27	42
5th	6500	25	770	8	0.5	0.2	1800	30	120	150	21000	37	2600	320	2.1	0.5	95	0.2	38	10	32	100
25th	17000	71	1600	20	0.9	0.9	8300	67	370	660	36000	200	11000	510	11	0.89	230	0.2	120	20	65	270
50th	19000	110	2600	56	1.1	1.8	14000	86	680	930	40000	300	16000	590	13	1.5	340	0.4	620	25	75	360
75th	20000	160	5100	170	1.2	3.8	16000	98	1300	1000	53000	1700	17000	670	19	3.9	520	0.6	830	34	86	2000
95th	21000	500	11000	380	1.3	5	22000	110	2500	1500	89000	2500	18000	920	32	6	1100	1.0	1600	46	96	3200
Maximum	22000	1600	17000	390	1.3	7	23000	230	3300	1600	110000	2900	20000	1000	47	25	1300	1.5	2400	50	100	5000
Stations [1]	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Samples [2]	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	25	40	41	41	41
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	34	-	20	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	41	41	7	3	26	ns	29	40	39	ns	36	ns	ns	39	17	39	0	40	ns	7	38
Table 2 [5]	ns	40	41	0	3	0	ns	0	39	38	ns	27	ns	ns	32	0	35	0	38	ns	0	14

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver are presented in Appendix A, Maps A6.2 to A6.8 respectively. The results of the Pearson Correlations analysis are given in Appendix B, Table B2.a to B2.c and the plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B2.1 to B2.6 respectively. The results of the regression analysis performed on the < 2mm and < 250µ soil fractions are given in Figures B2.7 to B2.15 for samples collected from within the mill and Figures B2.16 to B2.24 for tailing samples collected from around the mill.

The McKinley-Darragh Mill was built into the side of a rock hill. The mill is situated on and surrounded by mostly bare bedrock with scattered pockets of thin soil. At the top of the hill, between the mill and the tramway foundations, the soil was more contiguous but relatively shallow (Figure 4.2.2). To the north of the mill in the area below the machine shop was a large area of what appeared to be coal cinders. At the base of the mill, in the vicinity of the ore house and assay office, the soil consisted mostly of tailings. To the south of the original road into the mill, in a small bay off Leaf Lake, was another deposit of tailings.

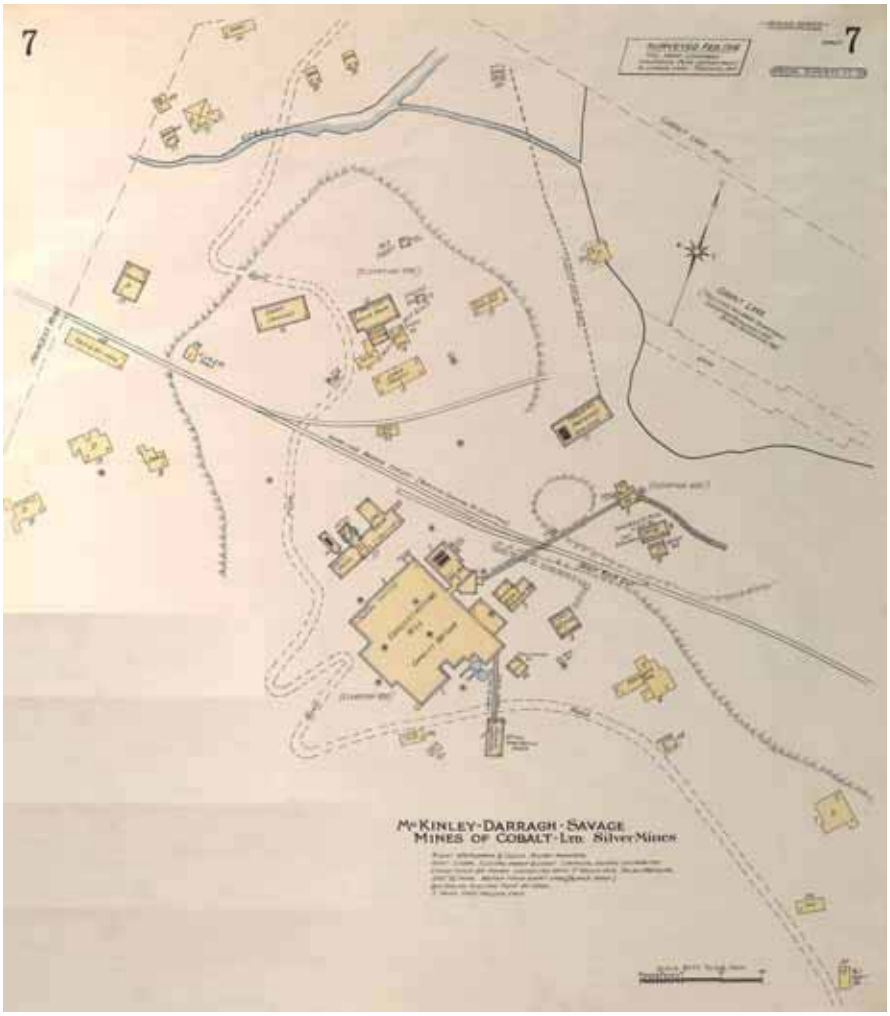


Figure 4.2.2: 1909 Fire Insurance Map of the McKinley-Darragh Mill site.

As can be seen in the concentration dot maps, these three areas had distinctly different soil chemistry. The pockets of soil within the mill and the thin layer of soil at the top of the mill had the highest concentrations of arsenic and other metals. Arsenic concentrations ranged from 4,100 to 17,000 µg/g, with a median concentration of 6,600 µg/g in the soil collected from this area. The next highest concentrations of arsenic and other metals were found in the tailings at the base of the mill and in the bay off Leaf Lake, with arsenic concentrations ranging from 1,600 to 3,800 µg/g. As would be expected, the range of concentrations was more consistent in the tailings than those observed in the soil from within the mill. Although the concentration of arsenic (770 to 1,500 µg/g) and metals was much lower in the coal cinder-like material to the north of the mill, concentrations of antimony, arsenic, cobalt, copper, lead, and silver still exceeded the *O. Reg 153-04 Table 2* standards in all of the coal cinder samples.

Only cobalt, nickel and zinc showed a significant correlation with arsenic at this site (Table B2.a). These correlations were only found in the soil from within and around the mill and not in the tailings samples, where arsenic concentrations did not correlate with any element (Tables B2.b and B2.c). Correlation analysis was not performed on the coal cinder field as only four samples were collected from this area.

There was a good one to one relationship between the < 2mm and < 250µ soil fractions for antimony, arsenic, cobalt, copper, lead, nickel and zinc in the tailing samples. There was a poor

relationship for silver and no relationship for mercury in the tailing samples. Given that the <250µ soil fraction of the tailing samples averaged 75% by weight, a good one-to-one correlation was expected. The relationship between the < 2mm and < 250µ soil fractions for the soil samples taken from within and at the top the mill was not as clear. Concentrations of arsenic, cobalt, copper, lead, mercury and zinc in the < 250µ fraction were 10% to 50% higher than those found in the < 2mm fraction. Nickel was the closest to a one to one correlation. Both antimony and silver were lower in the < 250µ fraction. The < 250µ soil fraction averaged 35% of the total sample by weight in the remaining samples.

Bio-accessibility results were highly variable between the three samples collected from the McKinley-Darragh Mill site. Variability was also high between elements in the same sample. Arsenic ranged from 18% to 120%, lead 5% to 110%, mercury 6% to 85%, and nickel 49% to 120% (see Table C49). There were a number of cases where bio-accessibility exceeded 100% indicating that the samples may not be homogenous. The three samples were distinctly different from each other in composition. Sample 3202 (sampling location 198) was fine grained material associated with coal cinders. Sample 3204 (sampling location 199) was a mixture of fine to coarse grained soil and building rubble. Sample 3214 (sampling location 203) was fine grained tailings collected at the base of the mill site. The non-homogeneity of the soil material at sampling locations 198 and 199 may have affected the bio-accessibilit y results.

Metal speciation by sequential extraction and arsenic and mercury availability were completed for samples 3204 (sampling location 199) and 3214 (sampling location 203). The metal speciation exchangeable fraction was very low ranging from 0% to 1.1% (see Table C50). The majority of the elements found in tailings sample 3214 were in the carbonate, Fe/Mn oxides, and organic fractions with residuals less than 20%. The metal speciation exchangeable fraction results for building sample 3204 were highly variable. This variability may help explain the range of bio-accessibility results for this sample. Extractable mercury was low in all three samples ranging from 1.2% to 3%. The availability of arsenic, both mobile and semi-mobile, was low in the coal cinders. Mobile arsenic ranged between 1% and 5% in the other two samples and semi-mobile arsenic ranged between 7% and 22% (see Table C51).

4.2.3 Heritage Silver Trail Site 4: Little Silver Vein and Nipissing Reduction Mill

The Little Silver Vein site (HST Site 4) offers tourists a view of an open "stope" or cut that remains after a vein is mined out. A trail leads from the stope to the Nipissing No. 96 "adit" at the base of a cliff, where tourists can enter the first 10 metres of the adit.

The Ore Reduction Mill was built in 1907 to concentrate low grade ore from Nipissing Mines. In 1908 it was operated as a custom mill under the name Nipissing Reduction Company. There is no information indicating the mill operated past 1912. The mill crushed the ore to No. 20 Mesh (0.85 mm) size and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings. The tailings are presumed to have flowed into the south-eastern bay of Cobalt Lake (the above background information is from Anderson, 1993).

Sampling at the HST Site 4 was conducted on August 17 and 18, 2004. Six locations were sampled; two sampling locations in the parking lot and four sampling locations along the walking trail to the adit (stations 226 to 231). The majority of the samples taken from the HST 4 sampling locations consisted of gravel used to build the parking lot and trail. The remaining samples were of waste rock fines originating from the mining activities.

Fifteen locations within the Nipissing Reduction Mill loading area immediately adjacent to the HST 4 parking lot were sampled on August 19, 2004 (stations 232 to 246). Figure 4.2.3.1 shows the location of the Nipissing Reduction Mill sampling locations with respect to the original mill buildings. Resampling to replace a number of 2004 samples lost by the laboratory was conducted on October 19, 2006.

The results of the chemical analysis of the samples collected from HST Site 4 and the Nipissing Reduction Mill are given in Appendix C, Tables C4.a and C4.b. Table C4.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C4.b. Results in Table C4.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.3.1 (HST 4) and in Table 4.2.3.2 (Nipissing Reduction Mill) below.

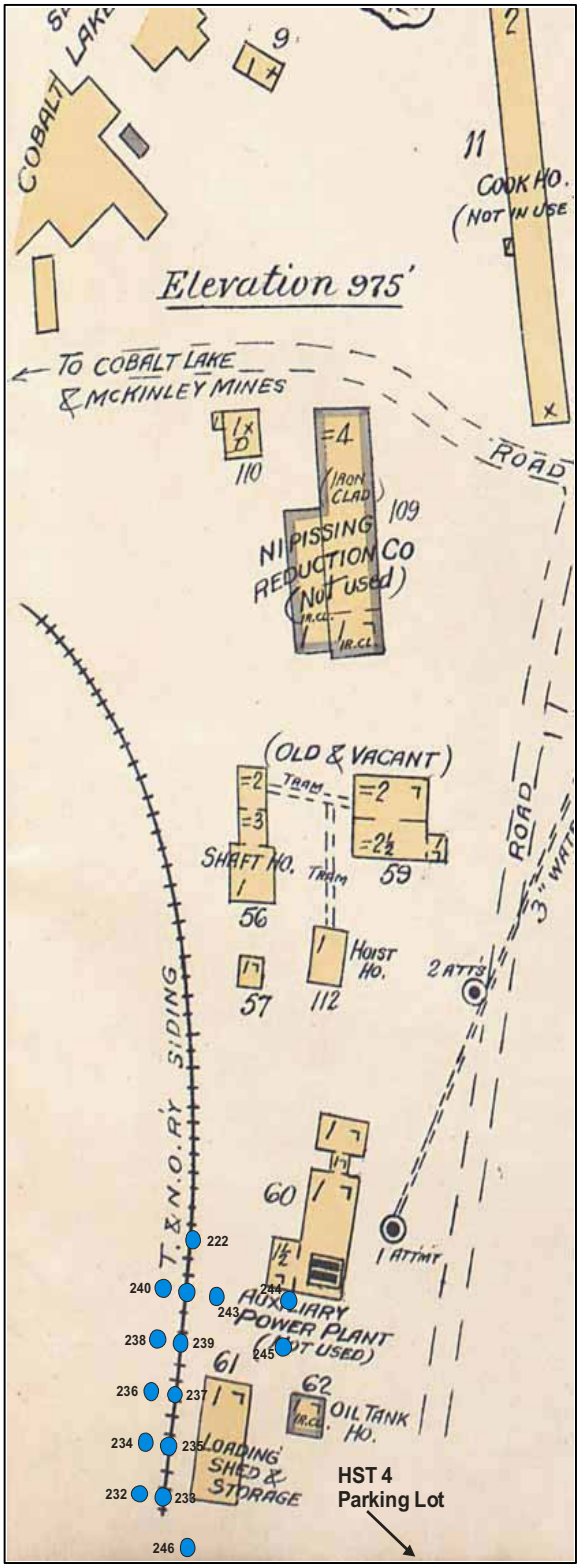


Figure: 4.2.3.1: 1909 Map of the Nipissing Reduction Mill

Table 4.2.3.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 4: Little Silver Vein

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	6700	0.2	2	12	0.2	0.5	2100	22	15	38	19000	11	1800	120	0.016	<0.3	28	<0.2	5	7	29	42
5th	7100	0.5	2	14	0.2	0.7	2400	25	15	40	19000	13	2100	140	0.019	<0.3	28	<0.2	5	8	31	44
25th	12000	1.1	4	33	0.3	4	5600	37	48	69	20000	56	6400	270	1.4	0.4	51	<0.2	8	24	42	58
50th	13000	2.4	46	36	0.5	4	7200	42	100	80	21000	81	7400	340	3.4	0.5	91	0.3	60	26	44	140
75th	13000	4	430	50	1.0	5	10000	44	140	170	32000	130	8200	400	7.5	1	140	0.4	100	28	48	200
95th	18000	12	2100	100	1.9	10	23000	110	460	890	41000	150	13000	550	19	2.6	170	0.7	110	93	90	310
Maximum	19000	12	2200	110	2.2	10	24000	120	600	930	43000	150	14000	570	20	2.7	200	0.7	120	100	94	350
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	3	-	0	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	9	6	0	2	10	ns	2	10	5	ns	4	ns	ns	10	1	10	0	12	ns	1	6
Table 2 [5]	ns	0	6	0	2	0	ns	0	9	3	ns	0	ns	ns	3	0	1	0	8	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.2.3.2: Summary of Chemical Analysis of Soil Samples from the Nippissing Reduction Mill Loading Area

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5600	10	1300	10	0.2	0.2	2000	24	260	51	11000	47	2900	160	2.7	<0.3	110	<0.2	29	13	20	59
5th	5800	11	1800	18	0.2	0.2	2100	26	610	63	13000	60	3200	190	40	0.6	480	<0.2	44	14	24	75
25th	6300	56	3100	38	0.3	0.2	3000	27	980	160	20000	150	3800	260	100	1.5	840	0.3	62	16	26	220
50th	7000	91	14000	46	0.4	0.2	3900	30	4300	250	22000	340	4700	310	290	2.8	3700	1.0	210	18	29	380
75th	8300	320	28000	60	0.5	0.6	5700	34	9900	420	25000	460	5300	400	640	5	8100	1.0	400	22	32	520
95th	9700	650	44000	81	0.9	1.2	16000	38	15000	580	31000	650	7500	480	1000	10	12000	1.0	610	75	39	840
Maximum	21000	1000	180000	92	1.0	6	19000	84	22000	690	35000	780	20000	550	1400	16	19000	1.0	730	100	100	1000
Stations [1]	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Samples [2]	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	1	-	1	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	35	35	0	0	3	ns	1	35	31	ns	28	ns	ns	35	18	35	0	35	ns	1	29
Table 2 [5]	ns	32	35	0	0	0	ns	0	35	20	ns	23	ns	ns	34	0	34	0	35	ns	0	7

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver for both locations are presented in Appendix A, Maps A7.2 to A7.8 respectively. The results of the Pearson Correlations analysis for the HST Site 4 stations are given in Appendix B, Table B3.a. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver at the HST 4 sites are given in Figures B3.a.1 to B3.a.6 respectively. The results of the regression analysis performed on the < 2mm and < 250µ soil fractions for the HST 4 sites are given in Figures B3.a.7 to B3.a.15.

The results of the Pearson Correlations analysis for the Nipissing Reduction Mill stations are given in Appendix B, Table B3.b and the plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver at the Nipissing Reduction Mill sites are given in Figures B3.b.1 to B3.b.6 respectively. The results of the regression analysis performed on the < 2mm and < 250µ soil fractions for the Nipissing Reduction Mill sites are given in Figures B3.b.7 to B3.b.15.

With the exception of two small areas, the concentrations of arsenic and other metals were quite low. This was expected as most of the historical site consists of clean gravel that was brought in for the parking lot and walking trail. Slightly elevated arsenic concentrations (82 to 140 µg/g) were found at the entrance to the adit where the gravel was mixed with some waste rock material. Significantly higher concentrations of arsenic (1,300 to 2,900 µg/g), cobalt, copper, nickel and silver were found at station 228. This is a small area of the trail that provides an example of exploratory blasting done on the rock outcrop and the ground was covered with waste rock from the blasting. Station 227, located in the north end of the parking lot, in an area that had been expanded using material that appears to have come from the area around the

auxiliary power plant of the Nipissing Reduction Mill, also had significant concentrations of arsenic (2,100 to 2,500 µg/g), cobalt, mercury, nickel and silver.

Although iron, mercury, molybdenum and selenium were significantly correlated with arsenic, these correlations were driven by two sites with high arsenic concentrations. There was generally no correlation with arsenic. There were good correlations between aluminum and magnesium, manganese, and vanadium, which was expected as most of the material was clean gravel. With the exception of antimony and arsenic, there were good one to one relationships between the < 2mm and < 250µ soil fractions for As, Co, Cu, Pb, Hg, Ni, Ag and Zn. For antimony, the < 250µ fraction was only 52% of the < 2mm fraction (Figure B3.b.7).

The remains of the railway siding, oil tank foundation and loading shed of the Nipissing Reduction Mill were readily visible from the parking lot at HST 4 at the time of the sampling. Although the 1909 Fire Insurance Map shows the loading shed on the east side of the railway siding, the remains of what appeared to be a loading dock approximately 25m long was observed on the west side. XRF screening of this area revealed highly elevetated concentrations of arsenic and other metals along a portion of the siding and at the back of the auxiliary power plant building. A sampling grid, 10 x 60 m, was established starting at the south end of the rail siding. Each grid was 5 m east to west by 10 m north to south, with six cells located along the rail line and 5 cells located on the loading dock to the west of the rail line (refer to Figure 4.2.3.2). Three additional sampling locations, 10 x 10 m, were established between the rail siding and the auxiliary power plant. Single composite 0 to 5 cm and 5 to 10 cm samples were collected from each sampling cell.

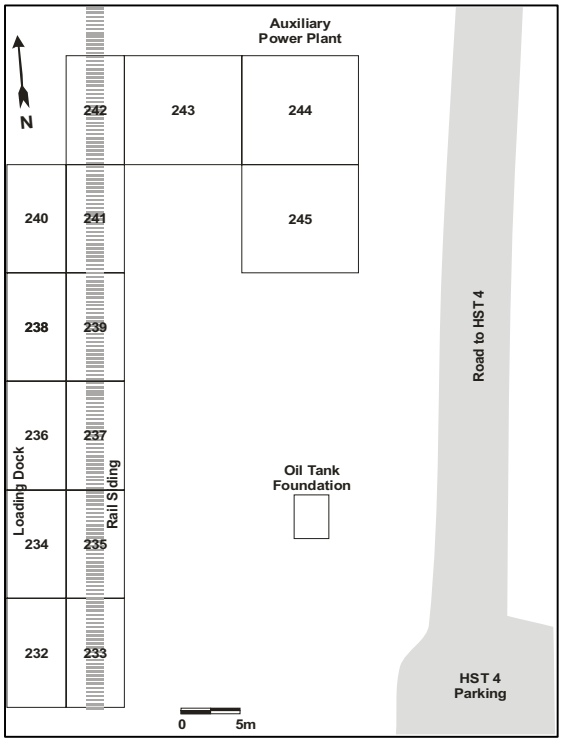


Figure 4.2.3.2: Nipissing Reduction Sampling Grid

The southern two thirds of the loading dock area and the adjacent rail bed (stations 232 to 239) had the highest concentrations of arsenic, cobalt, mercury and nickel. Arsenic concentrations in this area ranged from 1,300 to 180,000 µg/g, with a median concentration of 24,000 µg/g. There was no consistent pattern of change in concentration with depth. Concentrations of arsenic, cobalt, mercury, nickel and other metals dropped significantly in cells 240 to 242 with median concentrations 6 to 10 times lower in theses cells than those immediately to the south. XRF readings immediately north of these three cells had shown that concentrations of these elements continued to drop sharply. This drop off in contamination was evident visually in the vegetation. There was little or no vegetation growing in the grid area while healthy grass was growing on the old rail bed immediately north of the grid (Figures D81 to D91). The material in the grid area along the loading dock and rail bed was a light-grey medium textured sand. Some of this material had migrated downhill to the east of the rail bed.

In sampling cells 243 and 244, to the east of the rail bed and just south of the auxiliary power plant, arsenic, cobalt, mercury and nickel concentrations fell within the two areas described

above. Median arsenic concentrations were 7,300 µg/g. In sample cell 244, and to a lesser extent, sample cell 245, cinder-like material was mixed in with the sand. This material may have been coal cinders from the auxiliary power plant. Some of the material along the north side of cell 244 had been recently excavated with heavy machinery and appeared to be the source of the material used to enlarge the parking lot.

Excluding the one sample with 180,000 µg/g As, there were very strong correlations between arsenic, antimony, cobalt, mercury, nickel and zinc and to a lesser degree with copper and silver at the Nipissing Reduction Mill sampling locations. There were good one to one relationships between the < 2mm and < 250µ soil fractions for As, Co, Cu, Pb, Hg, Ni, Ag and Zn. For antimony, the < 250µ fraction was only 52% of the < 2mm fraction.

4.2.4 Heritage Silver Trail Site 5: Cart Lake Lookout

The Cart Lake Lookout (HST Site 5) consists of a small parking area, a picnic table, and a posted HST sign. The site is located at the northwest corner of Cart Lake on the road to HST Site 6 and is not on or directly adjacent to any mine, mill, or tailings area. The site overlooks the large tailings found in Cart Lake and provides views of the Silver Summit and Cobalt Provincial head frames located at the far end of the lake. There is also an old mining road exiting HST Site 5 on the west side of Cart Lake made out of waste rock.

Four locations were sampled at this site on August 17, 2004. Duplicate surface soil samples (0 to 5cm) were collected at each location. Samples of the clean gravel used to build the site were collected from two locations including the parking area and the area around the picnic table located at the lookout (stations 220 and 222 respectively). Samples of waste rock fine material were collected from two locations along the old mining road including an area immediately adjacent to the lookout and an area 180m south of the lookout (stations 221 and 223 respectively).

The results of the chemical analysis of the samples collected from HST Site 5 are given in Appendix C, Tables C5.a and C5.b. Table C5.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C5.b. Results in Table C5.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.4.1 below.

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at both locations are presented in Appendix A, Maps A8.2 to A8.8 respectively. The results of the Pearson Correlation analysis for the HST 5 stations are given in Appendix B, Table B4. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B4.1 to B4.6 respectively.

Table 4.2.4.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 5: Cart Lake Lookout

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	1700	0.7	4	4	0.1	1.7	3500	6	2	4	6100	12	13000	280	0.007	0.3	5	0.2	5	6	7	6
25th	6800	1.3	4	11	0.2	3	4800	26	27	45	13000	42	17000	300	0.18	0.3	32	0.2	7	7	32	52
50th	16000	3	120	16	0.6	6	30000	60	81	100	29000	60	18000	440	0.68	0.5	60	0.2	51	24	70	82
75th	23000	4	290	19	1.0	9	130000	91	120	190	44000	79	20000	570	1.4	0.7	88	0.2	110	70	97	110
Maximum	26000	7	400	19	1.1	10	300000	100	160	290	48000	110	29000	600	1.9	1.4	96	0.2	190	120	99	140
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	0	-	-	-	-	-	3	-	-	-	4	-	6	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	7	4	0	0	8	ns	4	6	4	ns	0	ns	ns	6	0	5	0	8	ns	4	0
Table 2 [5]	ns	0	4	0	0	0	ns	0	5	1	ns	0	ns	ns	0	0	0	0	4	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

As would be expected, the concentrations of arsenic and other metals in the gravel used to build the parking and lookout areas at HST Site 5 were very low and were below the *O.Reg 153-04 Table 1* standards. There were slightly higher concentrations of Ba, Be, Cr, Co, Cu, Fe, Pb, Hg, Ni, Ag, and Zn in areas where the underlying waste rock was exposed compared to the gravel found in the vicinity of the picnic tables. The waste rock fine material collected from the old mining road had elevated concentrations of arsenic and other metals, with arsenic ranging from 230 to 400 µg/g. The concentrations found in the waste rock material were similar to those found in other waste rock in the Cobalt-Coleman Mining Camp.

Correlation analysis of the data from HST Site 5 showed a strong correlation between almost all of the elements examined. These correlations are the result of the small number of samples taken at HST Site 5 (n=8) and the fact that half of the samples were of clean gravel while the other half were of waste rock fines having elevated concentrations of most elements. Correlations were performed on essentially two points, one high and one low, yielding artificially high correlations. There were too few samples to do a comparison between the < 2mm and < 250µ soil fractions.

4.2.5 Heritage Silver Trail Site 6: Nipissing No. 96 Mine Site

The Nipissing No. 96 Mine (HST Site 6) is located approximately 150m west of HST Site 5. This site consists of a parking lot, a winch house, a relocated head frame, and a platform overlooking the No. 96 slope. This area is comprised of either waste rock or of the gravel brought in for the parking lot and trail leading to the lookout platform.

Four locations were sampled on August 17, 2004. Two locations were sampled in the gravel of the parking lot and along the trail leading to the lookout platform (stations 217 and 219 respectively). Waste rock samples were also collected from two locations on either side of the path leading to the lookout platform including an area just west of the fence surrounding the head frame and in the vicinity of the old mining equipment display (stations 216 and 218 respectively). Composite 0 to 5 cm samples were collected in duplicate from each location. Waste rock fine material was collected from the waste rock areas only.

The results of the chemical analysis of the samples collected from HST Site 6 are given in Appendix C, Tables C6.a and C6.b. Table C6.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C6.b. Results in Table C6.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.5.1 below.

Table 4.2.5.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 6: Nippissing No. 96

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	1600	0.2	1	4	0.1	1.5	8300	6	2	3	5800	12	16000	290	0.007	1.0	4	0.2	5	6	7	5
25th	1900	0.4	5	4	0.1	1.7	23000	6	2	4	6400	13	24000	300	0.008	1.0	5	0.2	5	12	8	6
50th	10000	3	360	5	0.3	5	160000	46	76	92	21000	50	27000	400	0.56	1.1	63	0.2	34	70	47	74
75th	26000	7	1200	6	0.7	18	300000	99	200	830	54000	1900	27000	880	1.2	1.3	130	0.4	110	120	140	2000
Maximum	39000	7	1600	20	0.7	31	310000	120	230	1300	77000	4100	29000	1300	2.5	2.2	150	0.7	140	130	230	4700
Stations [1]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	2	-	-	-	-	-	4	-	-	-	4	-	6	0	-	-	-	-	-	4	-	-
Table 1 [4]	ns	5	4	0	0	8	ns	4	4	4	ns	3	ns	ns	4	0	4	0	8	ns	3	3
Table 2 [5]	ns	0	4	0	0	3	ns	0	4	3	ns	3	ns	ns	0	0	0	0	4	ns	2	3

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at both locations are presented in Appendix A, Maps A8.2 to A8.8 respectively. The results of the Pearson Correlations analysis for the HST 6 stations are given in Appendix B, Table B5. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B5.1 to B5.6 respectively.

The results of the sample analysis for HST Site 6 were very similar to HST Site 5. The gravel used to make the parking lot and walking trail had very low concentrations of arsenic and metals with no exceedances of *O.Reg. 153-04 Table 2* standards. Concentrations of arsenic and metals at the two waste rock sampling locations however were higher than those found in waste rock at HST Site 5. Arsenic concentrations ranged from 720 to 1,600 µg/g. Cadmium, cobalt, copper, lead silver and zinc were all above the *O. Reg 153-04 Table 2* standards in the waste rock fine samples.

Correlation analysis of the data from HST Site 6 showed a strong correlation between almost all of the elements. Similar to HST Site 5, these correlations were the result of the small number of samples taken (n=8) and the fact that ha lf of the samples were of clean gravel while the other half were of waste rock having elevated concentrations of most elements. Correlations were performed on essentially two points, one high and one low, yielding artificially high correlations. There were too few samples to do a comparison between the < 2mm and < 250µ soil fraction.

4.2.6 Heritage Silver Trail Site 7: Nipissing Low Grade Mill and Tailings

The Nipissing Low Grade Mill (HST Site 7) was located on the north end of Nipissing Hill, 280 m northeast of the Nipissing High Grade Mill. It was built in 1912 as a replacement for the Nipissing Reduction Mill and provided concentrates to the Nipissing High Grade Mill. The mill operated from 1913 to 1932 when it was closed as ore supplies were exhausted. The Low Grade Mill burned to the ground in 1934 and the site was cleaned up in 1935.

Processing of the ore at the Nipissing Low Grade Mill consisted mainly of grinding the ore to a No. 200 Mesh (0.075 mm) size and extracting the silver using cyanide. This fine grinding resulted in tailing slimes consisting of very fine sand and silt. Tailings from the Nipissing Low Grade Mill were deposited in a depression approximately 6 hectares in size located at the base of Nipissing Hill immediately north of the Low Grade Mill. The majority of the tailings originally deposited in this tailings dump have since migrated into Mill Creek. In the 1990's, a layer of clay topsoil was used to cap the tailings and the area was seeded (the above background

information is from Anderson, 1993).

Preliminary sampling of the Nipissing Low Grade Mill was conducted on October 26, 2003 at which time nine locations were sampled in the parking lot and the area around the top of the mill. Extensive sampling was conducted within the mill and the areas immediately adjacent to the mill on August 25, 31 and September 1, 2004. A total of 108 samples from 43 locations were collected in 2004. Resampling to replace a number of 2004 samples lost by the laboratory was conducted on October 18, 2006. The Nipissing Low Grade tailings located at the base of the mill were sampled on September 28 to 30, 2005. Nineteen locations were sampled in the tailings area. Single composite samples, comprised of ten cores, were collected from 5 x 5m areas at each location, at 0 to 10, 10 to 20, 20 to 30 and 30 to 40 cm depths.

The results of the chemical analysis of the samples collected from the Nipissing Low Grade Mill and the Nipissing Low Grade Tailings are given in Appendix C, Tables C7.a and C7.b. Table C7.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C7.b. Results in Table C7.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics, including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Nipissing Low Grade Mill and the Nipissing Low Grade Tailings are given in Tables 4.2.6.1 and 4.2.6.2 respectively.

Table 4.2.6.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 7: Nippissing Low Grade Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	2600	0.5	11	7	0.4	0.2	2400	14	3	5	9100	10	1300	160	0.01	0.4	12	0.2	1	7	11	8
5th	9200	29	950	8	0.5	0.2	5400	40	200	160	24000	100	5000	290	1.4	0.5	250	0.2	43	11	35	280
25th	13000	120	3400	26	0.7	0.6	12000	61	960	650	36000	370	12000	630	9.6	1.5	970	1.0	370	15	49	580
50th	18000	260	6800	70	0.8	1.1	17000	84	1800	1100	46000	630	18000	680	26	2.4	1800	1.0	640	21	74	920
75th	22000	520	15000	140	1.0	2.5	20000	100	3100	1500	51000	1300	22000	740	100	4	3600	1.0	1000	36	110	1600
95th	25000	980	47000	410	2.9	6	33000	120	10000	2400	66000	2500	25000	990	950	8	14000	1.8	1800	360	120	3800
Maximum	27000	2900	130000	1100	5.5	9	270000	140	27000	6400	110000	7700	34000	1300	2600	22	17000	4	5300	1200	130	4800
Stations [1]	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53	53
Samples [2]	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	116	98	112	116	116	116
OTR_{98} [3]	0	-	-	-	-	-	2	-	-	-	97	-	72	0	-	-	-	-	-	21	-	-
Table 1 [4]	ns	114	114	18	22	62	ns	74	114	112	ns	108	ns	ns	114	57	114	5	112	ns	40	111
Table 2 [5]	ns	114	114	3	22	0	ns	0	114	108	ns	103	ns	ns	83	0	114	0	109	ns	0	86

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver for the Nipissing Low Grade Mill (HST Site 7) are presented in Appendix A, Maps A9.2 to A9.8 respectively. The results of the Pearson Correlation analysis are given in Appendix B, Table B6.a. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for the HST Site 7 sites are given in Figures B6.a.1 to B6.a.6 respectively. The results of the regression analysis of the < 2mm and < 250µ soil fractions collected from HST Site 7 are given in Figures B6.a.7 to B6.a.15.

Table 4.2.6.2: Summary of Chemical Analysis of Soil Samples from the Nippissing Low Grade Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	10000	5	190	4	0.3	0.3	2900	31	52	39	15000	39	4800	270	0.86	<0.3	71	<0.2	5	10	35	72
5th	20000	21	1000	4	0.7	0.5	9800	84	180	160	31000	68	14000	590	2.4	0.4	200	<0.2	19	11	71	120
25th	23000	50	2400	6	0.8	0.8	16000	92	580	390	37000	220	19000	620	7.9	1.3	400	1.0	68	12	97	220
50th	24000	71	3900	9	0.9	1.1	17000	96	980	490	39000	240	20000	650	16	1.7	550	1.0	82	14	100	250
75th	25000	120	5100	16	0.9	1.5	19000	100	1200	640	40000	300	21000	680	22	2.7	860	1.0	110	16	110	330
95th	29000	180	7400	90	1.0	2.3	20000	110	1700	760	43000	460	22000	760	34	5	1200	1.0	160	30	130	520
Maximum	36000	230	8200	150	1.1	4	28000	180	2100	1200	45000	810	24000	820	43	10	1400	1.0	240	40	140	900
Stations [1]	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Samples [2]	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71
OTR_{98} [3]	7	-	-	-	-	-	0	-	-	-	65	-	63	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	71	71	0	0	36	ns	69	71	69	ns	64	ns	ns	71	18	71	0	71	ns	60	64
Table 2 [5]	ns	69	71	0	0	0	ns	0	71	66	ns	55	ns	ns	45	0	68	0	66	ns	0	3

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at Nipissing Low Grade Tailings are presented in Appendix A, Maps A10.2 to A10.8 respectively. The results of the Pearson Correlation analysis for the Nipissing Low Grade Tailings stations are given in Appendix B, Table B6.b. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B6.b.1 to B6.b.6 respectively.

The Nipissing Low Grade Mill was the largest mill in the Cobalt-Coleman Mining Camp and was a very complex area to sample. The mill is located at the north end of Nipissing Hill overlooking the town of Cobalt. The Mill's foundation was divided into 4 levels for sampling purposes; level 1 being at the top of the hill and level 4 located at the lowest level of the mill. The main public areas for this site consist of the parking lot, observation platform, level 1 of the mill, and the aerial tram foundations. The lower levels of the mill however can easily be accessed from the east and west sides. The 1909 Fire Insurance Map shows the configuration of the mill in 1909 which has not changed significantly since that time (Figure 4.2.6).

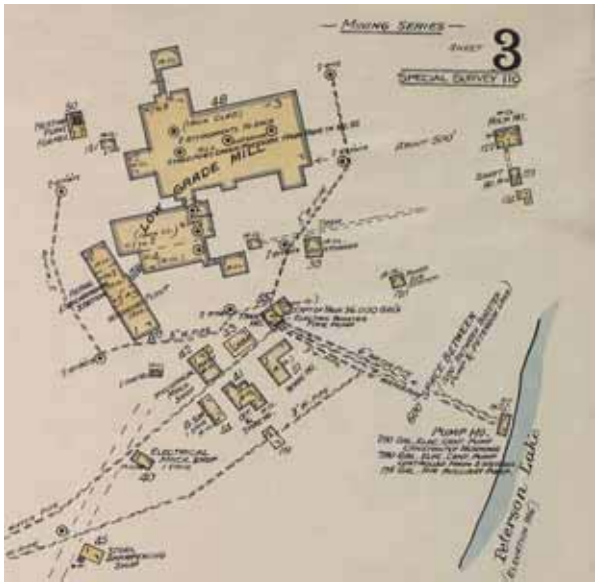


Figure 4.2.6: 1909 map of the Nipissing Low Grade Mill

The concentrations of arsenic and other metals were very high at the Nipissing Low Grade Mill. Arsenic concentrations ranged from 11 µg/g in the parking lot to 130,000 µg/g at sampling location 407 located in the cinder/slag material found in the vicinity of the old heating plant. The median arsenic concentration was 6,800 µg/g. All samples collected from the Nipissing Low Grade Mill exceeded the *O. Reg 153-04 Table 2* standards for antimony, arsenic, beryllium, cobalt, and nickel and the majority of the samples exceeded the Table 2 standards for copper, lead, mercury, silver, and zinc. Some of the highest concentrations of antimony in the Cobalt-Coleman Mining Camp were found at this location.

There was a distinct difference between the area within the actual foundations of the mill and the areas outside the mill's foundations to the east, west and north. Levels 1 and 2 of the mill consist of a concrete foundation and concrete floor. No tailings or mill waste was found on these levels and as a result no samples were collected. Levels 3 and 4 had a number of large circular

tank bases that still contained mill waste. The concentrations of arsenic and other metals in these tank bases were similar to those found in the tailings pond area below the mill. Arsenic concentrations ranged from 1,900 to 6,100 µg/g (stations 209 to 210, and 345 to 352). There were a couple of areas on the 3rd and 4th levels outside the tank bases that contained mill waste material that had higher levels of arsenic and metals. Arsenic concentrations ranged from 6,600 to 42,000 µg/g in these areas. Level 3b, immediately to the east of level 3 and about 2m higher, had concentrations of arsenic similar to the non-tank areas of levels 3 and 4. Overall the concentrations of arsenic found within the mill's foundations ranged from 1,900 to 42,000 µg/g with a median concentration of 3,900 µg/g.

Sampling outside the mill's foundations was concentrated in two main locations. The first was to the east of the mill starting at level 1 and following a trail along a drainage course to the base of the hill where the tailings start (sampling stations 381 to 392). The rocks along the drainage course were covered in a dark rust coloured stain. This area was sparsely vegetated with arsenic tolerant vegetation. The second area was located to the north and west of the main foundations (sampling stations 395 to 409). This area consisted of pockets of tailings, mill waste, black cinders and what appeared to be slag. Both these areas had significantly higher concentrations of arsenic and other metals. This pattern of higher concentrations of arsenic and metals in areas outside the mill's foundations is very distinct in the concentration dot maps.

Arsenic concentrations along the eastern side of the mill ranged from 1,100 to 43,000 µg/g, with a median concentration of 13,000 µg/g. The highest concentrations were found at sampling stations 388 to 390. Concentrations of antimony, cobalt, lead, mercury, nickel, and silver were also high in this area.

Arsenic concentrations to the northwest of the mill's foundations ranged from 3,200 to 130,000 µg/g with a median concentration of 15,000 µg/g. The highest concentrations of arsenic and other metals in this area were located in an area of black cinder-like material at stations 404 to 408 in the vicinity of the old heating plant. There was little or no vegetation growing in these areas of high arsenic concentrations.

There was generally very little correlation between the various metals at this site. Arsenic was correlated with antimony, cobalt and to a lesser extent with nickel. Given the wide range and type of materials found at the site, this was not expected. Even at sites where the material is of a more consistent nature, there is still little correlation between the different elements. There were good one to one relationships between the < 2mm and < 250µ soil fractions for Co, Cu, Pb, Ni, Ag and Zn. For antimony, the < 250µ fraction was only 69% of the < 2mm fraction and for arsenic the < 250µ fraction was only 85% of the < 2mm fraction. There was a good one to one relationship between the < 2mm and < 250µ soil fractions for mercury in all but five of the samples. The mercury concentrations in the <2mm fraction of the five outlying samples were significantly higher than the < 250µ fraction. This type of relationship, with higher concentrations being found in the larger soil fraction, suggests possible laboratory error in the mercury analysis for these five samples.

Bio-accessibility analysis was completed on three samples from the Nipissing Low Grade Mill. One sample was collected from a tank base beside the parking area while the other two samples were collected from two locations within the lower levels of the mill's foundations. The bio-accessibility of arsenic, cobalt, and copper were similar at 37%-55%, 52%-59%, and 37%-60% respectively (see Table C49). Lead, nickel, and zinc bio-accessibility were more variable at 78%-90%, 48%-69%, and 53%-74% respectively. Mercury bio-accessibility was lower at 10%-32%. Bio-accessibility of cadmium and molybdenum were also low; however, the total

concentrations were low. Silver bio-accessibility was lower in the samples exhibiting high total silver concentrations. Compared to other mills within the Cobalt-Coleman Mining Camp, the bio-accessibility results for the Nipissing Low Grade Mill fell within the middle of the ranges for all elements.

One sample from the Nipissing Low Grade Mill (sampling location 211, sample 3232) was analyzed for metals speciation, arsenic mobility, and mercury availability. This sample consisted of fine grained soil (92% by weight <250µ sieve) and variable metals concentrations (As = 5,100 µg/g, Co = 1,800 µg/g, Pb = 500 µg/g, and Hg = 25 µg/g). The metals speciation exchangeable and mobile arsenic fractions were very low (see Table C50). The arsenic and metals were generally split equally between the carbonate, Fe/Mn oxides, organic and residual fractions with some variation depending on the element. Mobile arsenic was 4% and semi-mobile arsenic was 25% (see Table C51). Extractable mercury was very low at 2%. These initial metal speciation results show that arsenic, cobalt, copper, nickel, lead, and zinc were, to varying degrees, semi-mobile and existed in multiple chemical forms or species. These elements and mercury, however, were not readily mobile or exchangeable. Many factors influence the chemical form or species of metals in soil, with pH and complexing ligands being the dominant factors (Evans, 2004). The species of the metal in soil affects its availability to human or ecological receptors.

The Nipissing Low Grade Tailings are situated immediately north of the Nipissing Low Grade Mill and slope from the south to the north. Although there were originally three levels to the tailings, there are only two remaining, and a large portion of the tailings from all levels have eroded into Mill Creek. A significant amount of the clay cap layer that was established to cover the tailings has also eroded. The tailings were sampled using a 50m by 50m grid oriented in a north to south direction. Stations 684 to 692 were located in the lower lever of the tailings at the north end and stations 695 to 701 were located in the upper level of the tailings at the south end. Enough erosion of the clay cap layer has occurred that bare tailings were found within a few metres of each grid location so that the clay cap material was not sampled. Vegetation was limited to the areas where the clay cap was still intact.

These tailings had the highest concentrations of arsenic and metals of any of the tailings sampled in the Cobalt-Coleman Mining Camp during the 2003 to 2007 sampling program. Arsenic concentration ranged from 190 to 8,200 µg/g with a median concentration of 3,900 µg/g. Elevated concentrations of antimony, cobalt, copper, lead, mercury, nickel and silver were also found. All 71 of the samples exceeded the *O. Reg 153-04 Table 2* standards for arsenic and cobalt, and the majority of these samples exceeded the Table 2 standards for antimony, copper, lead, mercury, nickel, and silver. There was no distinct pattern of arsenic or metal contamination within the tailings, either between the upper and lower levels or with changes in sample depth.

As with the mill, there was relatively poor correlation between the elements. Arsenic was correlated with cobalt and silver and to a lesser extent with antimony and nickel. The relationships had a lot of scatter in them (Figures B6.b.1 to B6.b.6). There was no < 250µ soil fraction analysis as the tailings were very finely ground.

4.2.7 Heritage Silver Trail Site 9: Right-of-Way Mine

In 1906, the Right-of-Way Mining Company Limited purchased the rights to take over and mine any discoveries of silver made within 50 feet on either side of the Temiskaming and Northern Ontario Railway. The Right-of-Way Mining Company sunk two shafts at the northern end of Cobalt Lake just east of the rail line and south of the Ferland Avenue bridge to determine if silver was present. The mine operated at a profit for two years but was closed in 1909. It would see continued re-activation over the next 78 years. Currently, the site consists of a parking lot

with a short set of stairs leading up to the main headframe building and one other building.

Samples were collected from four locations within the Right-of-Way Mine site on August 19, 2004 (stations 254 to 257). The four locations included gravel from the parking lot, the picnic table area located at the north end of the headframe, the south end of the headframe, and waste rock from an area 20m south of the headframe (refer to Map A11.1). Composite surface samples (0 to 5 cm) were collected in duplicate from each location.

The results of the chemical analysis of the samples collected from HST Site 9 are given in Appendix C, Tables C8.a and C8.b. Table C8.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C8.b. Results in Table C8.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.7.1 below.

Table 4.2.7.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 9: Right-of-Way Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	11000	2.0	7	26	0.3	0.2	5800	38	16	39	19000	10	7300	260	0.022	<0.3	31	<0.2	5	17	43	44
25th	11000	2.0	11	27	0.3	0.2	6500	40	17	49	20000	11	7700	280	0.048	<0.3	33	<0.2	5	22	47	52
50th	12000	3	76	28	0.3	0.2	7300	42	45	57	22000	32	8100	280	0.59	0.5	53	<0.2	5	24	50	90
75th	15000	4	1200	28	0.5	0.8	13000	69	360	220	28000	260	12000	380	2.0	2.5	230	<0.2	22	24	64	400
Maximum	24000	5	3000	30	1.1	2.7	17000	190	1300	390	45000	870	24000	710	4.6	10	750	<0.2	88	26	99	1200
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	2	-	2	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	8	5	0	0	2	ns	2	5	3	ns	3	ns	ns	5	2	5	0	8	ns	2	2
Table 2 [5]	ns	0	5	0	0	0	ns	0	5	2	ns	2	ns	ns	0	0	2	0	2	ns	0	2

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at Right-of-Way Mine are presented in Appendix A, Maps A11.2 to A11.8 respectively. The results of the Pearson Correlation analysis for the Right-of-Way Mine stations are given in Appendix B, Table B7. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver at are given in Figures B7.1 to B7.6 respectively.

The concentrations of arsenic and metals in the parking lot gravel were higher than typically found in other Heritage Silver Trail parking areas. The two parking lot gravel samples had arsenic concentrations of 100 and 780 µg/g. Cobalt, copper, lead, mercury, nickel and silver were also slightly elevated. Concentrations of arsenic and metals in the gravel from the headframe, with one exception, were below the *O. Reg. 153-04 Table 1 Background Standards*. One sample was marginally over the arsenic and cobalt Table 1 standards. The waste rock located 20m south of the headframe had arsenic and metals concentration more commonly found in tailings or mill waste than was typically found in the waste rock from other areas of the Cobalt-Coleman Mining Camp. Arsenic concentrations in the two samples were 2,400 and 3,000 µg/g.

As with HST Sites 5 and 6, there was a high degree of correlation between most of the elements in the eight samples collected from HST Site 9. This again is the result of performing

correlations on essentially two groups of data: low concentration gravel, and high concentration waste rock. This results in a straight line between two points. There were too few < 250µ soil fraction samples to perform regression analysis on the < 2mm and < 250µ results.

4.2.8 Heritage Silver Trail Site 10 & 11: Agnico Eagle Refinery and LaRose Blacksmith Shop

The Agnico Eagle Refinery (HST Site 10) and the LaRose Blacksmith Shop (HST Site 11) are located on Ferland Avenue immediately adjacent to one another and share the same parking area. In 1974, the original LaRose Mill was converted into a refinery to process complex ores, using acid and cyanide leaching to recover silver, gold and lead. The refinery was purchased by Agnico Eagle in 1982 and operated until 1989 when it was closed and cleaned up (the above background information is from Anderson, 1993). The LaRose Blacksmith shop was built by Fred LaRose in 1903 and has been moved to its present location.

Four locations were sampled around HST Sites 10 and 11 on August 19, 2004 (stations 260 to 263). The four locations include the parking area beside the LaRose Blacksmith Shop, the area immediately in front of the LaRose Blacksmith Shop, the area around the HST sign describing the history of the LaRose Blacksmith Shop, and an area in front of the gate that leads into the Agnico Eagle Refinery property (refer to Map A11.1). Composite surface samples (0 to 5 cm) were collected in duplicate from each location.

The results of the chemical analysis of the samples collected from HST Sites 10 and 11 are given in Appendix C, Tables C9.a and C9.b. Table C9.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C9.b. Results in Table C9.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.8.1 below.

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at HST Sites 10 and 11 are presented in Appendix A, Maps A11.2 to A11.8 respectively. The results of the Pearson Correlations analysis are given in Appendix B, Table B7. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B7.1 to B7.6 respectively.

Table 4.2.8.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 10 and 11

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	7000	3	71	15	0.2	0.2	5600	26	35	52	12000	29	6400	170	0.17	0.4	40	<0.2	8	22	25	45
25th	8200	6	300	20	0.2	0.2	7500	32	91	100	16000	76	6700	220	0.44	0.4	56	<0.2	10	23	33	92
50th	9600	6	350	25	0.3	0.2	8300	36	100	120	20000	86	6900	280	0.52	0.6	65	<0.2	23	25	43	98
75th	10000	11	2000	28	0.3	0.8	13000	41	460	420	21000	370	7500	280	3.9	0.7	180	<0.2	55	26	46	260
Maximum	12000	20	3200	37	0.3	1.4	14000	51	700	620	22000	540	8200	290	6.1	1.1	250	<0.2	87	28	49	380
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	7	7	0	0	2	ns	0	7	6	ns	3	ns	ns	6	0	6	0	7	ns	0	2
Table 2 [5]	ns	2	7	0	0	0	ns	0	6	3	ns	3	ns	ns	0	0	2	0	4	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Unlike the majority of the HST sites, a new parking lot did not need to be constructed at this site as the existing parking lot for the Agnico Eagle Refinery was used. As a result, clean gravel was not brought in for this site. This is reflected in the moderately elevated concentrations of arsenic and other metals at this location. Arsenic concentrations in the parking area and the two locations beside the LaRose blacksmith shop ranged from 71 to 930 µg/g. The arsenic concentrations in the two samples taken in front of the gate to the Agnico Eagle Refinery compound were 3,000 and 3,200 µg/g. The elevated arsenic and metal concentrations found around the LaRose blacksmith shop were most likely from vehicle traffic in and out of the refinery site. *O. Reg. 153-04 Table 2* standards were exceeded for arsenic at all four sampling locations.

There was a good relationship between arsenic and cobalt, copper, lead, mercury, nickel, silver and zinc at this location. There was no relationship between arsenic and antimony. There were too few < 250µ soil fraction samples to perform regression analysis on the < 2mm and < 250µ results.

4.2.9 Heritage Silver Trail Site 12: Nipissing No. 73 Meyer Shaft

The Nipissing No. 73 "Meyer" Shaft (HST Site 12) is located at the end of a short dead end road running north off of Hudson Bay Road just north of the hockey arena. Ore from this site was transported by overhead tramway to the Nipissing Low Grade Mill located 1000m south of the shaft.

Two locations at HST Site 12 were sampled on August 18, 2004 (stations 247 and 248, refer to MapA37). At the time of sampling there was a sign for the site posted at the beginning of the dead end road however the shaft could not be seen from this location because of a small woodlot. This woodlot was cut down the following year so that visitors could see the shaft without having to travel down the dead-end road. The two sampling locations included an area of gravel found at the end of the dead-end road where visitors can stop and view the shaft and a pile of waste rock located beside the road. The actual site was fenced off and not accessible by the public. Composite surface samples (0 to 5 cm) were collected in duplicate from each location.

The results of the chemical analysis of the samples collected from HST Site 12 are given in Appendix C, Tables C10.a and C10.b. Table C10.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C10.b. Results in Table C10.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.9.1 below.

Table 4.2.9.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 12: Nippissing Shaft No. 73

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	7000	3	59	14	0.2	0.2	4100	31	24	41	13000	51	5300	180	0.18	<0.3	31	<0.2	9	15	32	55
25th	7100	4	63	15	0.2	0.2	4200	32	24	62	13000	58	5400	180	0.24	<0.3	31	<0.2	17	16	33	58
50th	12000	6	980	24	0.5	1.7	10000	52	410	430	25000	630	12000	420	1.7	2.1	350	0.3	36	16	51	480
75th	17000	14	2100	32	0.7	3	16000	72	790	850	38000	1400	18000	660	3.4	4	670	0.3	83	16	70	910
Maximum	17000	33	2600	32	0.7	3	18000	74	800	1000	39000	1800	19000	680	3.9	4	690	0.4	180	16	72	940
Stations [1]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Samples [2]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	2	-	2	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	4	4	0	0	2	ns	1	4	2	ns	2	ns	ns	3	2	2	0	4	ns	0	2
Table 2 [5]	ns	1	4	0	0	0	ns	0	2	2	ns	2	ns	ns	0	0	2	0	2	ns	0	2

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

The results for this location were not analyzed (i.e., concentrations dot maps, Pearson Correlations) because there were only four samples taken from two sampling locations. The gravel from the roadway had slightly elevated concentrations of arsenic (59 and 64 µg/g) just above the *O. Reg. 153-04 Table 2* standard for arsenic. The waste rock fine material sampled from the east side of the road contained high concentrations of arsenic, lead and other metals (1,900 and 2,600 µg/g As and 1,200 and 1,800 µg/g Pb respectively). It is unlikely that visitors will travel down to the area where the samples were taken as the woodlot has been cut down allowing the shaft to be seen from Hudson Bay Road

4.2.10 Heritage Silver Trail Site 13: Willet Green Miller Memorial Site

The results for the Willet Green Miller Memorial Site (HST Site 13) have been combined with the results for parks and green spaces found under Section 4.3 of this report.

4.2.11 Heritage Silver Trail Site 15: Mile 104 Mill

The Mile 104 Mill (HST Site 15) located at Mile 104 on the Northern & Temiskaming Railroad was built in 1913. The mill was originally called the Northern Customs Concentrator. It initially used a gravity concentration process with flotation being added in 1916 and a cyanide plant added in 1917. It became the Bailey Mill in 1919, which then closed in 1922. The mill was purchase in 1922 after the original O'Brien mill burnt down and operated as the O'Brien Mill until 1940. The mill continued operation under various owners until it burnt down in October 1956. The mill crushed the ore to a No. 20 Mesh (0.85 mm) size and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings. The tailings from the mill were deposited into Crosswise Lake (the above background information is from Anderson, 1993).

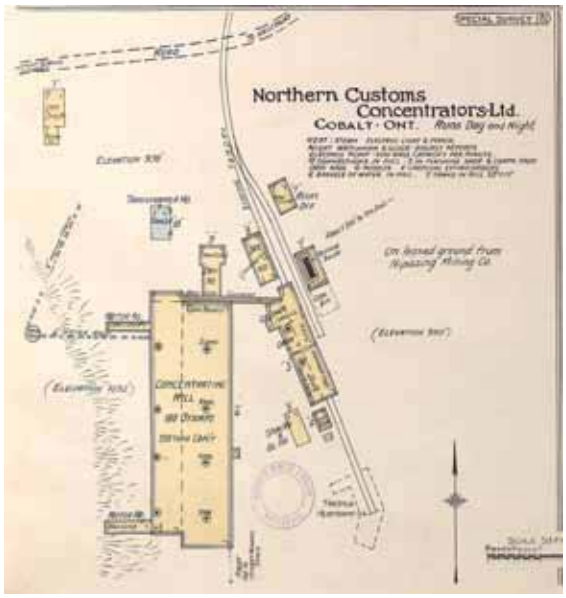


Figure 4.2.11.1: 1909 Fire Insurance Map of Mile 104 Mill

The majority of the sampling at HST Site 15 was conducted on August 24, 2004, at which time twenty one locations were sampled (stations 293 to 312). Two locations within the tailings located on either side of the road leading up to the parking lot at HST Site 15 were sampled on September 22, 2004 (stations 454 and 465). Resampling was conducted on October 18, 2006 to

replace a number of 2004 samples lost by the laboratory. Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

The results of the chemical analysis of the samples collected from HST Site 15 are given in Appendix C, Tables C11.a and C11.b. Table C11.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C11.b. Results in Table C11.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.11.1 below.

Table 4.2.11.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 15: Mile 104 Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	4100	0.6	610	4	0.2	0.2	6300	14	150	47	8500	38	11000	300	0.22	1.4	47	<0.2	9	7	14	52
5th	11000	1.0	1500	7	0.4	0.7	7600	44	660	120	23000	220	14000	350	0.32	2.7	160	<0.2	28	9	43	300
25th	18000	2.1	8700	31	0.7	1.4	11000	74	2600	830	38000	730	19000	430	2.9	5	590	0.3	49	14	79	610
50th	23000	3	14000	53	0.8	2.1	13000	86	4700	1300	46000	1200	21000	490	5.8	7	1000	1.0	130	23	100	930
75th	25000	15	22000	140	1.0	2.7	18000	97	9700	1700	51000	1800	23000	550	9.4	10	1900	1.0	410	34	110	1300
95th	26000	46	31000	260	1.4	4	70000	140	12000	2300	63000	2400	26000	830	31	21	2500	1.0	920	61	120	2300
Maximum	29000	80	33000	400	1.9	5	240000	140	13000	2400	66000	4400	29000	1000	79	27	4000	1.0	1200	120	120	3400
Stations [1]	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Samples [2]	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49
OTR_{98} [3]	1	-	-	-	-	-	3	-	-	-	42	-	41	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	44	49	6	3	46	ns	37	49	47	ns	47	ns	ns	48	47	49	0	49	ns	33	47
Table 2 [5]	ns	14	49	0	3	0	ns	0	49	44	ns	47	ns	ns	11	0	47	0	47	ns	0	37

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at HST Site 15 are presented in Appendix A, Maps A12.2 to A12.8 respectively. The results of the Pearson Correlations analysis are given in Appendix B, Table B9. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B9.1 to B9.6 respectively.

HST Site 15 is accessed by a road off of Cross Lake Road that leads to a parking lot located near the old loading shed along the Temiskiming and Northern Railway spur lines (Figure 4.2.11.1 above). There is a trail from the parking lot that runs along the south end of the mill to the upper level of the mill. The Mile 104 Mill foundation runs in a north-south direction and consists of two main levels. The upper level on the west side is comprised of three rows of massive concrete foundations that housed the ore crushing stamps. The lower level is on the east side of the mill closest to the parking lot and consists mainly of concrete floors and small pillars. There is a gap in the middle of the upper level that allows access from the lower level. There is a large pile of mill waste and crumbling concrete on the lower level against the base of the upper level foundations. The mill waste is up to 1.5 metres deep along the upper level foundation.

Concentrations of arsenic and other metals at HST Site 15 were very high. Although th e highest concentrations were not as high as those found at the Nipissing Low and High Grade Mills or the Buffalo High Grade Mill, the median concentrations were still very high and the range of

concentrations were much smaller than the other mills. The range of arsenic concentrations of samples collected from the mill's foundations was 9,000 to 33,000 µg/g with a median concentration of 21,000 µg/g (stations 297 to 304). Concentrations of cobalt, copper, lead, nickel, silver and zinc were also high within the mill's foundations with median concentrations of 8,200 µg/g Co, 1,600 µg/g Cu, 1,600 µg/g Pb, 1,800 µg/g Ni, 320 µg/g Ag, and 1,200 µg/g Zn. All samples from within the mill foundations exceeded the *O.Reg 153-04 Table 2* standards for arsenic, cobalt, copper, lead, nickel, silver and zinc.

In the gap mid-way along th e upper foundation, where water from the upper level can run down to the lower level (station 308), there were a number of deposits of purple cobalt bloom, refer to Figure 4.2.11.2. The precipitation of these minerals in this area has caused the mill waste to bind together up to 30 cm deep in places. X-ray Fluorescence Spectrometry readings of the surface of the cobalt bloom for arsenic and erythrite exceeded 100,000 ug/g.

Figure 4.2.11.2: Cobalt bloom at Stn. 308.

There was a large debris field sloping down from the lower mill foundations to the parking lot. At the south end of this debris field th ere was very little vegetation. In the middle of the debris field, where the ground was lower, there was a large area covered in Baltic Rush, the most arsenic tolerant plant growing in the Cobalt-Coleman Mining Camp (refer to Figure 4.2.11.3). In the area between the mill and the parking lot, excluding the Baltic Rush area, arsenic concentrations ranged from 5,700 to 16,000 µg/g with a median concentration of 9,700 µg/g. Concentrations of cobalt, copper, lead, nickel, silver and zinc were correspondingly lower in this area. All samples taken from the area between the mill's foundations and the parking lot exceeded the *O.Reg 153-04 Table 2* standards for arsenic, cobalt, copper, lead, nickel, silver and zinc.

In addition to being found in front of the mill, Baltic Rush was also observed growing on the tailings found on either side of the drive leading up to the parking lot adjacent to Cross Lake Road. Arsenic concentrations in areas covered by Baltic Rush were considerably lower than the rest of the site (although still considered high). Arsenic concentrations ranged from 1,100 to 4,900 µg/g with a median concentration of 2,100 µg/g. Cobalt, copper, lead, nickel, silver and zinc were also much lower in these areas. All samples collected from the areas where Baltic Rush was growing exceeded the *O.Reg 153-04 Table 2*standards for arsenic, cobalt, copper, lead, nickel, and silver.

Figure 4.2.11.3: Baltic Rush at Station 313

There was very little correlation between any of the elements at HST Site 15. Only cobalt and nickel were significantly correlated with arsenic. There was good one to one relationships between the < 2mm and < 250µ soil fractions for arsenic, cobalt, copper, lead, nickel and zinc. Excluding one anomalous mercury result, there was also a good one-to-one relationship for

mercury. There was a lot of scatter in the antimony and silver < 2mm vs. < 250µ soil fractions.

4.2.12 Heritage Silver Trail Site 16: Colonial Mine and Mill

The Colonial Mine (HST Site 16) and the Colonial Mill were located on the SW¼ of the S ½ of Lot 3, Concession VI, Coleman Township. The mill was built in 1908 and originally operated at a production rate of 30 tons per day. The mill changed ownership a number of times and went through a number of upgrades. In 1962 it was upgraded to a 200 ton per day capacity but was destroyed by a fire in November, 1962. The mill operated intermittently throughout most of its life. The initial mill crushed the ore to a No. 20 Mesh (0.85 mm) size and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings (the above background information is from Anderson, 1993). The Colonial Mill, although not part of the Heritage Silver Trail tour, is adjacent the Colonial Mine and as such will be discussed at the same time as the results from HST Site 16.

Sampling at HST Site 16 and the Colonial Mill was conducted on September 1 and 2, 2004. Seven locations were sampled, six locations along the Colonial Mill's foundations and seven sites within the mine waste located between the mine and the mill (refer to Map A13.1). Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

The results of the chemical analysis of the samples collected from HST Site 16 and from the Colonial Mill are given in Appendix C, Tables C12.a and C12.b. Table C12.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured *Ont. Reg. 153-04* are given in Table C12.b. Results in Table C12.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at HST Site 16 (the Colonial Mine) and the Colonial Mill are presented in Appendix A, Maps A13.2 to A13.8 respectively. The results of the Pearson Correlation analysis are given in Appendix B, Table B10.a, B10.b and B10.c respectively. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for HST Site16 are given in Figures B10.a.1 to B10.a.6 respectively. The results of the regression analysis of the < 2mm and < 250µ soil fractions from HST Site 16 are given in Figures B10.a.7 to B10.a.15. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for the Colonial Mine waste rock area are given in Figures B10.b.1 to B10.b.6 respectively. Results of the regression analysis of the < 2mm and < 250µ soil fractions for the Colonial Mine waste rock area are given in Figures B10.b.7 to B10.b.15. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for the Colonial Mill are given in Figures B10.c.1 to B10.c.6 respectively. The results of the regression analysis of the < 2mm and < 250µ soil fractions for the Colonial Mill are given in Figures B10.c.7 to B10.c.15.

Summary statistics, including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines, are given in Tables 4.2.12.1, 4.2.12.2 and 4.2.12.3 below for HST Site 16, the Colonial Mine and the Colonial Mill respectively.

Table 4.2.12.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 16: Colonial Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	1800	1.0	6	5	0.1	0.2	3400	6	2	3	6100	11	3900	280	0.0091	0.3	5	0.2	5	12	8	5
5th	1900	1.0	6	5	0.1	0.2	3500	9	2	4	6200	12	4000	290	0.011	0.4	6	0.2	5	12	8	5
25th	3500	1.0	36	8	0.13	0.2	7600	18	8	14	7900	14	11000	290	0.027	0.7	15	0.2	5	46	13	14
50th	14000	1	160	140	0.78	0.2	10000	87	87	64	34000	31	14000	480	0.24	1	84	0.2	5	46	54	91
75th	32000	14	4000	160	0.86	0.2	210000	100	1200	520	36000	300	22000	640	4.1	5	500	1	40	120	69	270
95th	33000	49	6100	260	1.1	3	280000	100	1600	4900	44000	1300	26000	700	95	10	630	1.4	320	130	79	1200
Maximum	33000	55	6900	350	1.3	3	290000	110	1700	8100	50000	1700	27000	710	130	13	680	1.5	400	130	82	1300
Stations [1]	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Samples [2]	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
OTR_{98} [3]	6	-	-	-	-	-	4	-	-	-	8	-	4	0	-	-	-	-	-	6	-	-
Table 1 [4]	ns	5	11	1	1	3	ns	8	8	6	ns	6	ns	ns	7	5	8	0	14	ns	0	5
Table 2 [5]	ns	4	11	0	1	0	ns	0	8	5	ns	5	ns	ns	2	0	5	0	5	ns	0	3

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.2.12.2: Summary of Chemical Analysis of Soil Samples from the Colonial Mine Waste Rock Area

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	10000	1.8	1300	8	0.1	0.2	1100	53	63	350	27000	140	6300	250	1.9	0.95	23	0.2	62	4	55	330
5th	13000	6.0	1300	13	0.15	0.2	1100	54	110	360	28000	320	8800	260	2	1.0	42	0.3	63	5	59	340
25th	16000	11.0	2800	20	0.33	0.88	3200	65	450	540	38000	740	14000	420	4.4	2.4	92	0.45	190	8	85	460
50th	19000	22	4700	32	0.44	1.8	18000	79	700	960	46000	1400	20000	620	6.8	5	220	1.0	280	20	100	550
75th	23000	56	7200	42	0.66	4.1	23000	86	1700	1300	110000	3000	21000	780	11.0	6	440	1.4	320	22	120	1000
95th	28000	110	23000	91	1.5	8	32000	110	2200	3200	160000	20000	26000	970	280	10	580	2.2	620	35	130	2700
Maximum	33000	110	23000	140	2	10	33000	120	2300	3200	230000	20000	28000	1100	280	10	600	2.2	990	47	140	3400
Stations [1]	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Samples [2]	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	14	-	11	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	16	16	0	2	11	ns	9	16	16	ns	16	ns	ns	16	12	15	3	16	ns	11	16
Table 2 [5]	ns	11	16	0	2	0	ns	0	16	16	ns	15	ns	ns	4	0	11	0	16	ns	0	6

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.2.12.3: Summary of Chemical Analysis of Soil Samples from the Colonial Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	21000	18.0	2900	10	0.4	0.37	5800	69	1200	630	36000	280	15000	520	1.5	2.9	360	0.2	110	7	89	250
5th	22000	20.0	3400	11	0.45	0.42	6100	81	1400	900	36000	400	16000	550	1.8	3.3	390	0.2	130	8	91	300
25th	22000	25.0	7000	18	0.58	0.68	8000	110	2000	1100	41000	620	20000	630	2.4	4.9	440	1	190	11	99	470
50th	23000	32	7600	31	0.77	0.87	20000	130	2300	1300	43000	850	23000	690	3.1	7	490	1.0	260	13	120	580
75th	26000	48	8200	40	0.79	1.6	26000	180	2600	2000	48000	1300	24000	740	5.9	12	620	1	330	19	120	750
95th	27000	70	13000	55	1	2	28000	880	4500	3000	54000	1600	28000	900	450	21	1200	1.0	450	20	130	1200
Maximum	28000	110	17000	82	1	2	31000	880	4700	3400	66000	2000	28000	970	540	22	1200	1	540	21	130	1500
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	19	-	17	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	19	19	0	0	8	ns	18	19	19	ns	19	ns	ns	19	19	19	0	19	ns	17	19
Table 2 [5]	ns	19	19	0	0	0	ns	2	19	19	ns	19	ns	ns	3	0	19	0	19	ns	0	9

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

HST Site 16 includes two parking lots, the lower parking lot is located by some old mine buildings and a large waste rock dump overlooking the north end of Crosswise Lake while the upper parking lot is located by the Colonial Mine adit entrance. The main attraction at HST Site 16 is the guided tour of the adit run by the Historical Society. Concentrations of arsenic and other metals in the gravel taken from the two parking lots were low. This was expected as the parking lots were constructed with clean gravel. The lower parking lot had slightly higher concentrations of arsenic and other metals which is most likely due to the migration of contaminated material from the adjacent waste rock dump. The trail from the upper parking lot to the adit entrance, which consists of a mixture of gravel and small waste rock, was marginally

elevated in arsenic (90 µg/g). The main area of contamination at HST Site 16 was found in the vicinity of the foundations of the old buildings (stations 421 to 424) where arsenic concentrations ranged from 1,100 to 6,900 µg/g. Cobalt, copper, lead, mercury, nickel, silver and zinc were also significantly elevated at these sampling locations.

Statistical analysis of the results from HST Site 16 show arsenic concentrations were highly correlated to antimony, cobalt, molybdenum, nickel and selenium. There was also a high degree of correlation between other elements. This high degree of correleation was the result of performing correlations on essentially two groups of data: low concentration clean gravel, and high concentration waste rock or mine and mill waste. In reality, there was a lot of scatter in the data. There was a good one-to-one relationship between the < 2mm and < 250µ results for all elements except antimony if the results of sample number 1899 from station 421 is excluded. As with other locations, the antimony concentrations in the < 250µ soil fraction were lower than the < 2mm fraction.

Immediately to the north of the lower parking lot is a large waste rock dump that provides an excellent view of the north end of Crosswise Lake and the tailings area along Farr Creek (stations 417 and 420). There is a gated old road that leads to a lower level of the mine works that consists of waste rock (stations 425 to 428). There was evidence of people using this area and of waste rock being removed by heavy machinery. The waste rock was mainly the typical grey coloured rock mixed with fine material. There were however, large areas of rust coloured stains on the rock and fine materials (Figure 4.2.12.1).

Figure 4.2.12.1: Rust stained waste rock at stn. 420

In areas where the grey waste rock was rust stained, arsenic and metal concentrations were much higher than the typical grey waste rock. Arsenic concentrations of the more typical grey waste rock were in the 1,600 µg/g range. Rust stained waste rock arsenic concentrations typically ranged from 2,100 to 8,200 µg/g and had high concentrations of other metals. Lead concentrations in the stained areas were much higher that typically found in waste rock. The median concentration of lead in the waste rock area was 1,400 µg/g. The rust stained waste rock also had very high concentrations of iron compared to the typical waste rock. One of the waste rock sampling locations along the old road leading to the lower level of the mine works had significantly higher arsenic and lead concentrations than found elsewhere at the site (23,000 µg/g As and 20,000 µg/g Pb respectfully).

Statistical analysis of the data collected from the waste rock area indicated there were significant correlations between arsenic and copper, lead and mercury. In this case, the correlations were driven by the very high concentrations found at station 426. There is a lot of scatter in the data despite the fact that concentrations of other elements tended to increase with increasing arsenic concentrations. There are one-to-one relationships for the < 2mm and < 250µ soil fractions for cobalt, copper, lead, nickel, silver and zinc. There is also a one to one relationship for mercury if the results for station 426 are excluded. Arsenic shows a two to one relationship between the < 250µ and < 2mm soil fractions, with twice as much arsenic in the fine fraction of the waste rock. As with the HST Site 16 results, the antimony concentrations in the < 250µ soil fraction were lower than the < 2mm fractions.

The Colonial Mill's foundations are located at the northeast end of the main waste rock dump at the base of the hill. Only the concrete foundations and a large amount of mill waste remained at the time of sampling. Of the six locations sampled, three were within the lower levels of the mill's foundations while the remaining sites were located along the west side of the foundations in a large area of mill waste. The mill waste at stations 432 and 433, and to a lesser extent at stations 434 and 435, had a significant amount of coarse wood fibres mixed in with the mineral component of the waste (refer to Figure 4.2.12.2).

Figure 4.2.12.2: Mill waste at station 432.

Arsenic concentrations ranged from 2,900 to 17,000 µg/g with a median concentration of 7,600 µg/g. Concentrations of antimony, cobalt, copper, lead, mercury, nickel, silver and lead were also high at the mill site with all samples exceeding the *O.Reg. 153-04 Table 2* standards for these elements. There was evidence of recent footprints throughout the mill waste at the mill site despite being well removed from the Heritage Silver Trail site.

The results of the Pearson Correlations analysis of the results from the mill foundations show no significant correlations between arsenic and any other element. While there is a general trend of increasing concentrations of other elements with increasing arsenic concentrations, there is a high degree of scatter in the data. There is a general one to one relationship for arsenic, cobalt, copper, lead, nickel, silver and zinc between the < 2mm and < 250µ soil fractions. There is also a one to one relationship for mercury if the results for station 431 are not included in the analysis. As with the other locations, the < 250µ soil fraction results for antimony were lower than the < 2mm soil fractions.

4.2.13 Heritage Silver Trail Site 17: Nova Scotia Mill and Tailings

The Nova Scotia Mill (HST Site 17) was located on the east side of Peterson Lake on the SW¼ of the N½ of Lot 3, Concession V, Coleman Township. It was built in 1908-1909 and began operation in 1910. The mill was capable of processing 200 tons of ore a day. In 1912 the operation was sold to the Dominion Reduction Company to be used as a custom mill. The mill closed in 1922 due to low silver prices. It re-opened briefly in 1934. The mill processes included gravity separation, a cyanide process, and a flotation process to allow processing of ore from any of the local mines.

Tailings from the mill were deposited into the eastern arm of Peterson Lake and behind a tailing dam in a valley directly north of the mill. It is estimated that there are 50,000 tons of tailings behind the dam covering an area of approximately 3.8 hectares. Most of the tailings in the eastern arm of Peterson Lake have been mined and reprocessed at other mills over the years. Tailings from the tailings dam area have migrated into Crosswise Lake via a creek and through a breach in the original dam back into Peterson Lake. Tailings from Peterson Lake have migrated down Peterson Creek (the above background information is from Anderson, 1993).

Sampling at the Novia Scotia Mill was conducted on August 24 and 25, 2004. The Dominion Reduction Tailings were sampled on June 16, 2005. Seventy samples were collected from thirty one sampling locations at the Nova Scotia Mill and thirty samples were collected from five

sampling locations on the Dominion Reduction Tailings (refer to Map A14.1). Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

The results of the chemical analysis of the samples collected from HST Site 17 are given in Appendix C, Tables C13.a and C13.b. Table C13.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C13.b. Results in Table C13.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Nova Scotia Mill and the Dominion Reduction Tailings are given in Table 4.2.13.1 and 4.2.13.2 respectively.

Table 4.2.13.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 17: Nova Scotia (Dominion Reduction) Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	2000	0.9	6	5	0.1	0.2	3800	9	2	4	6400	9	3400	180	0.016	<0.3	5	<0.2	5	8	8	5
5th	7500	2.0	290	9	0.2	0.2	5700	32	61	45	14000	20	4600	270	0.11	0.5	44	<0.2	6	9	27	58
25th	17000	3	1200	10	0.8	0.4	9200	73	280	130	32000	160	15000	490	0.86	0.9	100	<0.2	35	10	72	110
50th	20000	9.4	2000	26	1.0	0.6	15000	84	440	190	35000	240	19000	540	1.6	1.2	130	<0.2	62	14	94	170
75th	22000	190	11000	60	1.1	2.9	17000	90	1900	2000	51000	2300	20000	590	6.4	9	510	1.0	340	28	100	1600
95th	28000	690	25000	120	1.6	5	41000	130	3800	7700	82000	11000	27000	820	83	42	930	1.4	610	55	180	3100
Maximum	35000	960	28000	300	1.9	7	280000	170	6900	9000	110000	12000	30000	1100	210	52	1200	5	740	130	250	3600
Stations [1]	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
Samples [2]	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
OTR_{98} [3]	7	-	-	-	-	-	2	-	-	-	48	-	46	0	-	-	-	-	-	3	-	-
Table 1 [4]	ns	69	69	2	8	25	ns	52	68	62	ns	57	ns	ns	65	22	66	2	70	ns	42	36
Table 2 [5]	ns	30	69	0	8	0	ns	0	67	31	ns	37	ns	ns	15	6	31	0	60	ns	1	22

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.2.13.2: Summary of Chemical Analysis of Soil Samples from Dominion Reduction Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	19000	1.0	630	8	0.9	0.2	13000	74	180	110	33000	140	18000	460	0.47	<0.3	79	1.0	28	8	91	88
5th	19000	1.5	790	8	0.9	0.2	14000	78	190	110	33000	150	19000	460	0.5	0.4	80	1.0	30	8	91	90
25th	21000	5	1300	10	1.0	0.3	16000	80	430	130	36000	180	20000	520	1.1	0.8	130	1.0	38	11	99	130
50th	22000	11	2000	12	1.1	0.4	18000	84	490	160	37000	230	21000	540	1.3	0.9	150	1.0	50	12	110	160
75th	23000	13	2400	12	1.1	0.5	19000	89	690	210	39000	290	22000	570	1.6	1.3	180	1.0	57	13	110	200
95th	24000	17	3500	13	1.2	0.6	21000	95	780	250	40000	330	23000	590	2.0	1.6	190	1.0	74	19	120	210
Maximum	24000	17	4000	13	1.2	0.7	22000	97	810	250	41000	350	23000	600	2.1	2.1	200	1.0	88	23	120	220
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	24	-	30	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	28	30	0	0	0	ns	30	30	30	ns	30	ns	ns	30	0	30	0	30	ns	28	11
Table 2 [5]	ns	6	30	0	0	0	ns	0	30	5	ns	18	ns	ns	0	0	14	0	30	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at the Nova Scotia Mill and the Dominion Reduction Tailings are presented in Appendix A, Maps A14.2 to A14.8 respectively. The results of the Pearson Correlations analysis are given in Appendix B, Table B11.a and B11.b respectively. The plots of the relationship of arsenic to

antimony, cobalt, lead, mercury, nickel and silver for the Nova Scotia Mill are given in Figures B11.a.1 to B11.a.6 respectively. The results of the regression analysis of the < 2mm and < 250µ soil fractions from the Nova Scotia Mill are given in Figures B11.a.7 to B11.a.15. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for the Dominion Reduction Tailings are given in Figures B11.b.1 to B11.b.6 respectively. The results of the regression analysis of the < 2mm and < 250µ soil fractions for the Dominion Reduction Tailings are given in Figures B11.b.7 to B11.b.15.

Figure 4.2.13.1: Photograph showing HST Site 17 parking area, tailings dam and mill foundations.

HST Site 17 (Nova Scotia Mill) consists of a parking lot east of Peterson Lake at the base of the Dominion Reduction Tailings dam. The Nova Scotia Mill foundations are located approximately 50 metres to the south of the parking lot on the side of a hill (refer to Figure 4.2.13.1). The area between the parking lot and the base of the hill consists of sparsely vegetated tailings with pieces of waste rock and mill waste scattered on the surface. It appeared that the waste rock and mill waste originating from a waste rock dump just to the east of the mill was being used to build the base of the parking lot. Water from the Dominion Reduction Tailings seeps through the tailings dam, along the tailings between the parking lot and mill, and through a culvert to Peterson Lake.

Sampling was divided into three areas, the lower tailings around the parking lot, the mill's foundations, and the tailings behind the tailing dam. Arsenic concentrations at HST Site 17 ranged from 6 µg/g in the parking lot gravel to 28,000 µg/g in the red mine waste at stations 333 and 334. The median arsenic concentration was 2,000 µg/g. All but one parking lot gravel sample exceeded the *O. Reg. 153-04 Table 2* standard for arsenic. Concentrations of antimony, cobalt, copper, lead, mercury, nickel, and silver were also significantly elevated in the lower tailings and the mill foundations.

The lower tailings that had not been contaminated with waste rock or mill concentrate had arsenic concentrations ranging from 190 to 3,000 µg/g with a median concentration of 1,600 µg/g. The debris and mill waste from the mill's foundations could be classified into two types of material. The first consisted of building debris, grey to brown mill waste and some waste rock. The second of a rust red porous material spherical in shape roughly 3 to 6 mm in diameter. This material was associated with much finer particles of the same material. The surface of this material was often covered in pink erythrite bloom (Figure 4.2.13.2).

Figure 4.2.13.2: Red mill waste at Stn. 333

The main concentration of this rust coloured porous material was found at stations 333 and 334 however it was also found at stations 337 and 338 within the mill's foundations and at stations

319, 320 and 327 located in the lower tailings area. As well as its distinct physical appearance, this material had the highest concentrations of antimony, arsenic, lead and iron (170 to 650 µg/g Sb, 8,600 to 28,000 µg/g As, 2,300 to 11,000 µg/g Pb, and 51,000 to 89,000 µg/g Fe respectively) found at HST Site 17. In comparison, the concentrations of lead and iron in the more typical mill waste and debris found at this site ranged from 22 to 2,500 µg/g Pb and 14,000 to 57,000 µg/g Fe.

Concentrations of arsenic in the Dominion Reduction Tailings behind the tailings dam ranged from 600 to 4,000 µg/g with a median concentration of 2,000 µg/g. These concentrations were slightly higher than those found in the lower tailings found below the tailings dam. Concentrations of other metals such as cobalt, lead and nickel were also higher in the tailings above the dam than those below the dam.

There were good correlations between arsenic concentrations and the concentrations of cobalt, copper, molybdenum and nickel at HST Site 17. Although the concentrations of antimony, lead, mercury and silver also tended to increase with increases in arsenic concentration, there was a lot of scatter in the data. There was a good one to one relationship between the concentrations of cobalt, copper, lead, mercury, nickel, silver and zinc between the < 2mm and < 250µ soil fractions. Concentrations of antimony and arsenic in the < 250µ soil fraction were only 75% of the concentrations in the < 2mm fraction.

There was a lot of scatter in the data resulting in a poor correlation with arsenic despite the fact that the concentrations of the other elements tended to increase with increases in arsenic concentration. There was a good correlation between aluminum and other elements such as barium, iron, magnesium, manganese, and vanadium indicating that the tailings were all from the same ore body. Analysis of < 250µ soil fraction was not performed on the Dominion Reduction Tailings.

4.2.14 Heritage Silver Trail Site 18: Crown Reserve Mine

The Crown Reserve Mine is located on the south-western shores of Kerr Lake (refer to Figure 4.2.14). The mine produced 20 million ounces of silver in the period l908-l948. The silver veins lay beneath Kern Lake, which was drained to allow mining. The majority of tailings now lie beneath the waters of Kerr Lake (Sandy Cline, 1982). This site includes the foundations of the Silverleaf Mine shaft, support buildings, and signage depicting how Kerr Lake was drained during the mining operation. There was no mill at this location.

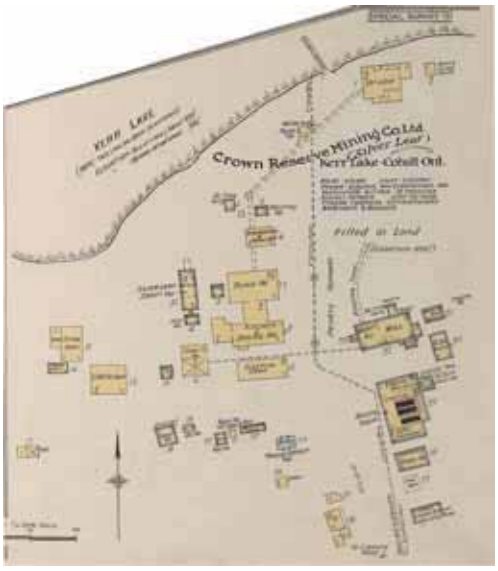


Figure 4.2.14: 1916 map of Crown Reserve

Eighteen samples from nine locations were collected at HST Site 18 on August 26, 2004 (refer to Map A15.1). As the area consisted of gravel, mine waste, and building debris, all samples were collected at a depth of 0 to 5 cm using a trowel from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum 10 trowel samples.

The results of the chemical analysis of the samples collected from HST Site 18 are given in Appendix C, Tables C14.a and C14.b. Table C14.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table*

1 Background Standards have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C14.b. Results in Table C14.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.14.1 below.

Table 4.2.14.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 18: Kerr Lake Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	1700	1.0	6	5	0.1	0.2	1500	7	1	3	5600	11	7200	280	0.007	1.0	4	<0.2	5	5	7	5
5th	1700	4	6	5	0.1	0.2	1600	7	2	4	5600	11	10000	280	0.007	1.2	5	<0.2	5	5	8	5
25th	9200	16	3000	22	0.4	3	20000	41	210	440	20000	700	18000	370	2.2	3	110	0.5	71	19	41	780
50th	17000	34	6000	28	0.9	7	26000	76	1000	1100	48000	2200	22000	540	5.2	4	220	1.0	180	32	96	1900
75th	21000	45	11000	33	1.3	8	56000	97	2000	1800	66000	2800	25000	790	5.6	6	350	1.1	210	45	110	2100
95th	24000	65	33000	51	1.5	9	290000	140	8200	2300	130000	5700	35000	880	8.5	10	900	1.9	280	130	190	2700
Maximum	24000	73	33000	62	1.9	10	300000	140	8600	2600	130000	7000	35000	950	11	11	930	2.0	290	140	200	2900
Stations [1]	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Samples [2]	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
OTR_{98} [3]	0	-	-	-	-	-	4	-	-	-	12	-	14	0	-	-	-	-	-	3	-	-
Table 1 [4]	ns	17	16	0	5	14	ns	10	16	16	ns	16	ns	ns	16	14	16	1	18	ns	10	15
Table 2 [5]	ns	15	16	0	5	0	ns	0	16	14	ns	14	ns	ns	1	0	12	0	16	ns	0	14

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at HST Site 18 are presented in Appendix A, Maps A15.2 to A15.8 respectively. The results of the Pearson Correlations analysis are given in Appendix B, Table B12. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for HST Site 18 are given in Figures B12.1 to B12.6 respectively. The results of the regression analysis between the < 2mm and < 250µ soil fractions at HST Site 18 are given in Figures B12.7 to B12.15.

HST Site 18 is a very small site consisting of a gravel road, a small parking area on the edge of the lake, and the foundations of the mine shaft and other buildings. The gravel from the parking area had very low concentrations of arsenic and metals (6 µg/g As) and all samples were well below *O. Reg. 153-04 Table 1 Background Standards*. Concentrations of arsenic in the thin soil around the mine's foundations were high, ranging from 770 to 33,000 µg/g with a median concentration of 6,000 µg/g. Concentrations of antimony, cobalt, copper, nickel, silver and zinc were also high with the majority of samples exceeding the *O. Reg. 153-04 Table 2* standards for these elements. The highest concentrations were found in the foundations at stations 356 to 360. Concentrations were lower around the Heritage Silver Trail signs located at stations 354 and 361. There was a lot of scatter in the data and arsenic concentrations were not correlated with any other element. There are good one to one correlations between the < 2mm and < 250µ soil fractions for cobalt, copper, lead, mercury, nickel, silver and zinc. There is also a one to one relationship for arsenic if the two outlier data points are excluded. There is no relationship between the < 2mm and < 250µ soil fraction results for antimony.

4.2.15 Heritage Silver Trail Site 19: Silver Sidewalk

The Silver Sidewalk (HST Site 19) was not a major mine or mill site but a site of historical interest only. It consists of a small rock cut surrounded by a chain link fence, two parking areas, an elevated platform and a sign detailing the history of the site. The area around the rock cut accessible to the public consists of native soil with small amounts of waste rock present.

Six samples from three sampling locations were collected at HST Site 19 on August 20, 2004 (refer to Map A15.1). The three locations included an area between the platform and the sign, the parking area to the west of the observation platform, and an area of native soil along the west side of the fence surrounding the rock cut. Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

The results of the chemical analysis of the samples collected from HST Site 19 are given in Appendix C, Tables C15.a and C15.b. Table C15.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C15.b. Results in Table C15.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.15.1 below.

Table 4.2.15.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Site 19: Silver Sidewalk

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	2100	2.0	6	6	0.1	0.2	5000	8	2	5	6700	12	5200	300	0.07	<0.3	6	<0.2	5	18	8	7
25th	5200	2.0	33	14	0.2	0.2	8000	19	9	12	9600	17	6400	340	0.09	0.4	17	<0.2	5	20	16	17
50th	15000	2.0	120	38	0.4	0.2	12000	47	28	32	18000	29	8800	410	0.16	0.7	48	<0.2	5	23	36	48
75th	17000	3	140	46	0.4	0.2	210000	49	32	38	20000	35	22000	460	0.21	1.0	53	<0.2	8	96	42	72
Maximum	17000	4	190	48	0.4	0.2	280000	50	46	81	21000	41	29000	500	0.30	1.1	62	0.3	14	130	44	100
Stations [1]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Samples [2]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
OTR_{98} [3]	0	-	-	-	-	-	2	-	-	-	0	-	2	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	6	4	0	0	0	ns	0	4	0	ns	0	ns	ns	1	0	4	0	6	ns	0	0
Table 2 [5]	ns	0	4	0	0	0	ns	0	1	0	ns	0	ns	ns	0	0	0	0	0	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at HST Site 19 are presented in Appendix A, Maps A116.2 to A16.8 respectively. The results of the Pearson Correlations analysis are given in Appendix B, Table B13. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver for HST Site 18 are given in Figures B13.1 to B13.6 respectively. There were too few < 250µ soil fractions results for a regression analysis to be performed.

As would be expected, concentrations of arsenic and other metals were low at this location. The gravel used for the parking lot was below *O. Reg. 153-04 Table 2* standards for all elements tested. Arsenic concentrations in the gravel were 6 µg/g. The soil by the side of and along the fence had low levels of contamination of antimony, arsenic, cobalt, mercury, nickel and silver. Only arsenic was consistently above the O. Reg. 153-04 Table 2 standards at these two sites with concentrations ranging between 110 to 190 µg/g.

Similar to other locations, the Pearson Correlations analysis yielded a large number of significant correlations because of the small number of samples characterized by both clean gravel and contaminated soil. These correlations are the result of interpreting a line between two distinct groups of data, while in reality, there are no real correlations within the data.

4.2.16 Heritage Silver Trail Site: Cobalt Lake Mine

The Cobalt Lake Mine was located on the southeast shore of Cobalt Lake. It was built in 1911 and operated until 1916 when production was moved to the Cobalt Reduction Mill. The mill crushed the ore to a No. 20 Mesh (0.85 mm) size and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings. The tailings were deposited into a bay located at the southeast end of the Cobalt Lake. Most of these tailings ended up in the Cobalt Lake Mine following a mining accident that resulted in the flooding of the mine.

In 1951 the Hellens Mill was built on the site of the former mine to re-treat the tailings from Cobalt Lake. The mill processed tailings from both Cobalt Lake and the Temiskaming Mill until 1955. The mill was reopened from 1967 to 1969 to process tailings from the lake elsewhere in the camp. The mill was demolished in 1985. The mill ground the tailings to a No. 200 Mesh (0.075 mm) and included a cyanide process to enhance silver recovery. Tailings from the Hellens Mill were initially deposited into Cobalt Lake but due to the high cyanide content of the tailings they were pumped to the Cart Lake tailings containment area (the above background information is from Anderson, 1993).

Sampling at Heritage Silver Trail Cobalt Lake Mine site was conducted on August 26, 2004. Twenty-seven samples were collected from fourteen sampling locations (refer to Map A16.1). Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

The Cobalt Lake Mine site is not a numbered stop on the Heritage Silver Trail however there is a parking lot beside the road and a sign that provides a history of the site. The site consists of the foundations of the Hellens Mill and a winch house for the drag line used to mine the tailings from the lake to the north of the mill. There are five levels to the Hellens Mill's foundations. Only the upper two levels had mine wastes in them at the time of sampling. The lower three levels consisted of concrete walls and floors and there was nothing to sample in these areas. One location was sampled in the waste rock parking area (station 367). Two areas were sampled in the upper level of the mill's foundations and four locations were sampled in the second level of the mill's foundations where piles of mill waste were found around old tank bases (stations 368 to 374). One sampling location was established on the top of the waste rock pile to the northwest of the mill and three sampling locations were established around the winch house (stations 375 to 378). Two locations were sampled within the tailings located at the base of the mill's foundations (stations 370 and 380).

The results of the chemical analysis of the samples collected from Cobalt Lake Mine site are given in Appendix C, Tables C16.a and C16.b. Table C16.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C16.b. Results in Table C16.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.2.16.1 below.

Table 4.2.16.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Cobalt Lake Mine Site

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	19000	12	530	5	0.7	0.2	6400	93	160	180	35000	100	16000	480	1.6	0.3	100	0.2	18	5	85	120
5th	19000	12	550	6	0.7	0.2	7400	94	170	200	35000	110	17000	510	1.9	0.9	110	0.2	53	6	86	140
25th	20000	18	960	8	0.8	0.2	12000	97	240	260	36000	150	17000	540	3.2	1.6	130	0.2	84	8	89	200
50th	20000	33	1400	11	0.8	0.4	13000	100	310	370	39000	250	18000	560	3.8	2.0	180	0.2	130	11	94	240
75th	22000	50	2200	16	1	0.84	16000	110	470	820	41000	350	19000	630	10	3	260	0.2	300	13	100	420
95th	25000	480	21000	46	1.3	7	20000	120	4600	5900	56000	2200	22000	690	67	22	1600	0.88	1900	16	120	2200
Maximum	27000	930	39000	47	1.4	14	21000	120	8100	12000	64000	4200	23000	700	2600	44	3400	1.1	2600	18	120	3800
Stations [1]	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Samples [2]	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	27	-	26	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	27	27	0	2	5	ns	27	27	27	ns	24	ns	ns	27	8	27	0	27	ns	16	23
Table 2 [5]	ns	22	27	0	2	1	ns	0	27	22	ns	16	ns	ns	7	1	18	0	26	ns	0	4

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentration dot maps for arsenic, antimony, lead, mercury, cobalt, nickel and silver at Cobalt Lake Mine site are presented in Appendix A, Maps A16.2 to A16.8 respectively. The results of the Pearson Correlation analysis for the Cobalt Lake Mine site are given in Appendix B, Table B14. The plots of the relationship of arsenic to antimony, cobalt, lead, mercury, nickel and silver are given in Figures B14.1 to B14.6 respectively. There were too few < 250µ soil fractions for this site for a regression analysis to be performed.

Concentrations of arsenic ranged from 530 to 39,000 µg/g with a median concentration of 1,400 µg/g. Concentrations of antimony, cobalt, copper, lead, nickel, silver, and to a lesser extent mercury were also high. The highest concentration of arsenic and metals was found in the northern-most tank base on the upper level of the foundations (station 369). The arsenic concentrations at this location were ten times higher than the next highest sampling location. Arsenic concentrations exceeded the *O. Reg. 153-04 Table 2* standards at all locations and the *O. Reg. 153-04 Table 2* standards were exceeded at the majority of locations for antimony, cobalt, copper, lead, nickel, and silver.

The results of the Pearson Correlations analysis show significant correlations between most elements. These correlations were however largely driven by the two very high results from station 369. Removing station 369 from the analysis however still resulted in significant correlations between arsenic and cobalt, copper, mercury, and nickel. There were significant correlations of aluminum with iron, magnesium, manganese, and vanadium indicating that the majority of the material around the mill was of similar origin.

4.2.17 Heritage Silver Trail Site: Nipissing High Grade Mill and Tailings

The Nipissing High Grade Mill located on Nipissing Hill along the east side of Cobalt Lake was built in 1911. The mill operated until 1918 when a new process was developed at the Low Grade Mill to replace the costly amalgamation process. The silver was recovered from the ore in a combined cyanide and mercury amalgamation process. Tailings from the Nipissing High Grade Mill were deposited in a small tailings area located half way down the hill (the above background information is from Anderson, 1993).

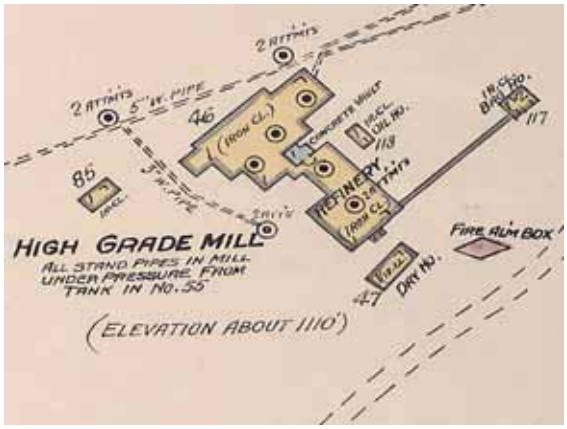

HIGH GRADE MILL
ALL STAND PIPES IN MILL UNDER PRESSURE FROM TANK IN No. 55
(ELEVATION ABOUT 1110')
FIRE ALM BOX
DRY HO.
REFINERY

Figure 4.2.17.1:1916 Fire Insurance Map of NHG Mill

At the time of sampling, the Nipissing High Grade Mill consisted of concrete foundations, building debris, and areas of waste rock, tailings, and bedrock. As shown in Appendix A - Map A2, the concrete foundations of the main processing area and vault are located in the northwest corner of the site. Building debris was located immediately to the northeast. The main foundations were built on the side of a hill that sloped northwards towards Nipissing Road and eventually Cobalt Lake. The concrete foundation of the bag house was present on the eastern portion of the site. The bag house was originally used to filter and recycle mercury vapours from the ore refining process (Dumaresq, 1993). A number of rock cuts, some filled with waste rock, transected the eastern portion of the site. Tour parking was located on the southern portion of the site.

Evidence was noted of the following uses by local residents and tourists during the assessment of the Nipissing High Grade Mill site: tour related activities including the reading of interpretative signs, walking around the site, and the parking of vehicles; rock collecting; children playing with rocks and debris; and bush parties. Adjoining land uses included road right of ways and vacant, forested or former mill/mine properties to the east, south, and west of the Nipissing High Grade Mill. To the north, across Nipissing Road, residential properties have been built adjacent to a depression containing the remaining mill tailings and a concrete dam. No samples were collected from the Nipissing High Grade Mill tailings in 2003.

A total of 177 samples (including duplicates) were collected from 48 sampling locations at the Nipissing High Grade Mill in October, 2003. A sampling grid using 5 metre intervals was established around the mill's foundations to reference all sampling locations (refer to Maps A17.1a and A17.1b). The grid started 30 metres to the east of the bag house foundation near the top of the hill and extended 20 metres west of the lower foundations for an overall, east-west length of 125 metres. The grid varied in length between 25 to 50 metres in the north-south direction. Composite soil samples were collected from the 5 metre square grid cells if soil texture and XRF readings were consistent across the entire cell. Due to the presence of physical obstacles (i.e. bedrock, waste rock, building debris, foundations) or variation in soil texture and/or XRF readings, composite soil samples from portions of a grid cell (between 1 and 5 metres square) or discrete samples were also collected. A small number of sampling locations were established outside of the sampling grid. Soil samples were collected to a maximum depth of 20 cm at the Nipissing High Grade Mill.

The results of the chemical analysis of the samples collected from Nipissing High Grade Mill and Tailings are given in Appendix C, Tables C17.a and C17.b. Table C17.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C17.b. Results in Table C17.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Nipissing High Grade Mill and the Nipissing High Grade Tailings are given in Table 4.2.17.1 and 4.2.17.2 respectively.

Table 4.2.17.1: Summary of Chemical Analysis of Soil Samples from Heritage Silver Trail Nippissing High Grade Mill Site

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	700	11	270	4	0.5	0.2	1100	2	130	32	21000	13	190	14	0.5	0.1	72	0.2	8	6	7	14
5th	14000	22	930	9	0.58	1.2	3300	48	290	76	26000	41	4400	400	4.8	0.5	190	0.4	24	11	41	140
25th	18000	100	2900	27	0.7	2.4	5400	62	1000	320	31000	130	7200	610	19	3	610	1.0	74	16	54	350
50th	23000	210	11000	56	0.8	6.2	7900	91	4800	1100	47000	330	19000	760	70	16	2500	24.0	170	21	79	780
75th	27000	310	30000	82	1.0	10	14000	120	13000	2100	58000	620	28000	930	180	62	6100	24.0	450	31	130	1300
95th	30000	1200	91000	130	1.3	15	26000	170	20000	8900	70000	1800	34000	1100	410	340	10000	25	1300	41	150	2200
Maximum	33000	3700	160000	290	1.4	25	48000	1100	54000	24000	170000	2900	41000	1200	2100	1100	53000	25	19000	91	170	23000
Stations [1]	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
Samples [2]	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	177	7	120	177	177	177
OTR_{98} [3]	37	-	-	-	-	-	0	-	-	-	111	-	93	0	-	-	-	-	-	1	-	-
Table 1 [4]	ns	177	177	2	10	173	ns	127	177	166	ns	137	ns	ns	177	134	177	4	120	ns	82	159
Table 2 [5]	ns	174	177	0	10	20	ns	1	177	146	ns	113	ns	ns	156	61	169	4	115	ns	0	112

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

A large number of the 177 soil samples that were collected from the Nipissing High Grade Mill site exceeded the background and generic *O. Reg. 153/04* soil standards. All one hundred and seventy-seven samples (2mm soil fraction) exceeded both background and generic standards for arsenic and cobalt (see Table 4.2.17.1). Antimony exceeded the generic criterion for 98% of the samples, silver 96%, nickel 95%, mercury 88%, copper 82%, and lead 63% of the samples respectively.

The level and range of concentrations of the majority of elements were significantly greater than those found at the other three mill sites sampled in 2003. Arsenic ranged from 270 to 160,000 µg/g, antimony 11 to 3,700 µg/g, cobalt 130 to 54,000 µg/g, lead 13 to 2,900 µg/g, mercury 0.5 to 2,100 µg/g, nickel 180 to 53,000 µg/g, and silver 23 to 19,000 µg/g in the 2 mm soil fraction.

The spatial distribution of arsenic, antimony, cobalt, lead, mercury and silver at the Nipissing High Grade Mill are presented in Appendix A, Maps A17.2 to A17.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The spatial pattern of arsenic, antimony, and cobalt at the mill site were similar, with the highest concentrations found in the main foundations north of the old vault structure and at the base of the foundations. The next highest concentrations were located in the area around the bag house foundations. This pattern appeared to be consistent with the major ore processing areas at the mill (Anderson, 1993). Arsenic, antimony and cobalt were major constituents of the Cobalt area ore (Boyle and Dass, 1971 and Dumaresq, 1993).

The spatial pattern of lead was more evenly distributed over the site. The highest concentrations, however, were still located on the main mill foundations and building debris field. The higher lead concentrations appeared to be consistent with the major ore processing areas at the mill site. Lead was also a constituent of the Cobalt area ore (Boyle and Dass, 1971) although sources of lead comtamination to this site may also originate from a number of domestic uses such as leaded gasoline or leaded paint. The highest mercury concentrations were found around the bag house foundations and just north of the vault. Silver concentrations were evenly spread across the site with the lowest concentrations found no rth-east of the bag house foundations. The highest silver concentrations were found in the remains of a small wood structure north of the main foundations (sampling stations 174 and 175, grid reference 48/74). This area contained a fine grained light coloured soil material and the remains of burlap sacking. It is unknown what this area of the mill was formerly used for and therefore what the high silver concentrations may be related to.

The soil texture at the Nipissing High Grade Mill was highly variable, ranging from what appeared to be natural soil with an organic A horizon to products of various stages of the milling

and refining processes, including fine to coarse grained tailings and wood fibre debris. Pink erythrite mineralization was also present on the soil material and the concrete at the site.

There were only a few significant correlations between elements due to the variable soil texture. The correlation of elemental concentrations in soil can be useful in determining origin of soil material and for remedial applications. There was a weak correlation between aluminum, vanadium, and magnesium. These are naturally occurring crustal elements and are normally found correlated with each other and also with iron and chromium in natural soil (Jones et al., 2004). There was also a correlation between antimony, arsenic, cadmium, cobalt, and nickel (see Figures B15.a.1 to B15.a.6). These elements, with the exception of cadmium, were major constituents of the Cobalt area ore (Boyle and Dass, 1971 and Dumaresq, 1993). The overall correlation of these elements, their spatial patterns, and a comparison with typical background soil concentrations (Boyle and Dass, 1971 and Province of Ontario, 2004a) indicate that the soil material on the Nipissing High Grade Mill site was generally comprised of waste (tailings) from the processing and refining of Cobalt area ore. Mercury and silver were not correlated with any other element. A few outlying data points created the correlation observed between mercury and zinc. Mercury was both a constituent of the ore and was used to process the ore to assist in silver recovery. Mercury was recovered via the bag house; this removal process may have resulted in the lack of correlation between mercury and other elements. Similarly, silver was selectively removed from the parent ore as it was the focus of the milling process. In the parent ore, silver would be correlated with other elements (i.e., arsenic, cobalt); in the tailings a large percentage of the silver was removed resulting in no correlation between silver and other elements.

The results of the correlation analysis show that although some elements correlate strongly, the majority of the elements exceeding the background and generic standards are not correlated. Specific areas of the Nipissing High Grade Mill site were found to be contaminated with individual elements while other areas contained high concentrations of multiple elements. This has implications for the management or remediation of the Nipissing High Grade Mill site, as one element may not be suitable as a marker contaminant for all contaminants of concern. Therefore, the spatial pattern and concentrations of each element of concern should be taken into consideration in future decisions regarding the site.

There was a linear relationship between the 2 mm and 250µ soil fractions with a slope of 1.0 for most elements that fell within analytical error (see Figures B15.a.7 to B15.a.15). In other words, chemical concentrations for most elements were the same (within analytical error) between the 2 mm and 250µ soil fractions. One exception was mercury, as there was 25% more mercury in the 250µ fraction than in the 2 mm fraction.

The bio-accessibility of arsenic, cobalt, copper, nickel, silver, and zinc were high and consistent between the eight samples analyzed with the exception of sample 3118 from sampling location 175 (Grid 48/74). Median bio-accessibility of arsenic, cobalt, copper, nickel, silver, and zinc were 61%, 73%, 51%, 71%, 57%, and 68% respectively, (see Table C49). The median bio-accessibility of lead was 71% however three of the eight samples had low bio-accessibility. Bio-accessibility of mercury was low, ranging from 0.5% to 12%. Total element concentrations in the 250µ soil fraction ranged from 420 to 190,000 µg/g for arsenic, from 420 to 55,000 µg/g for cobalt, and from 99 to 2,300 µg/g for lead.

The Nipissing High Grade Tailings were sampled on September 22, 2004. Twenty-six samples at nine locations were collected (see Map A22.1). Seven of the sampling locations were located above the remains of the concrete tailings dam and two were located below the dam. Stations 466 to 470 and 473 were established on the banks of the creek that runs through the tailings.

Much of the tailings have been washed from the tailings area into Cobalt Lake. Concretions of tailings with ethryite formations have formed on elevated areas, such as at station 474.

A large number of 26 the soil samples collected from the Nipissing High Grade Tailings site exceeded the background and generic *O. Reg. 153/04* soil standards. All 26 samples (2mm soil fraction) exceeded both background and generic standards for arsenic and cobalt (see Table 4.2.17.2). Antimony exceeded the generic criterion for 100% of the samples, silver 38%, nickel 100%, mercury 46%, copper 100%, and cobalt 100% of the samples. The level and range of concentrations of the majority of elements were similar to those found at the Nipissing High Grade Mill sites sampled in 2003.

Table 4.2.17.2: Summary of Chemical Analysis of Soil Samples from the Nippissing High Grade Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	7400	20	6400	4	0.77	0.2	2100	25	1800	250	21000	40	20000	430	1.7	7.7	530	0.66	7	3	28	150
5th	14000	22	8200	5	0.78	0.2	3300	54	3200	360	30000	46	23000	450	2.7	18	1100	1.0	7	4	52	180
25th	29000	47	12000	7	0.86	0.2	5800	97	4600	560	44000	66	28000	520	4.7	27	1600	1.0	10	7	110	220
50th	33000	59	16000	16	0.96	0.2	14000	100	5300	880	49000	83	30000	640	9.6	36	1900	1.0	14	11	110	260
75th	36000	120	19000	18	1.1	0	17000	120	5800	1000	52000	100	34000	830	120	61	2100	1.0	37	17	130	390
95th	39000	3800	120000	43	1.2	0.5	34000	140	25000	1600	55000	440	38000	1100	3500	140	20000	1	330	19	160	2300
Maximum	41000	5000	170000	54	1.2	0.57	44000	170	34000	2300	56000	700	39000	1100	5600	170	26000	5000	700	21	170	3700
Stations [1]	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Samples [2]	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
OTR_{98} [3]	22	-	-	-	-	-	0	-	-	-	24	-	26	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	26	26	0	0	0	ns	24	26	26	ns	3	ns	ns	26	26	26	1	26	ns	23	25
Table 2 [5]	ns	26	26	0	0	0	ns	0	26	26	ns	2	ns	ns	12	10	26	1	10	ns	0	6

[1] - number of stations sampled at this location

[2] - number of samples analyzed for this element from this location

[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline

[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*

[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*

ns - no *Reg. 153/04 Standard* for this element

- all results are expressed in µg/g dry weight

The spatial distribution of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel and silver at the Nipissing High Grade Tailings are presented in Appendix A (Maps A22.2 to A22.8 respectively). The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The spatial pattern and concentrations of arsenic, antimony, cobalt, lead, nickel, and silver at the Nipissing High Grade Tailings site were similar at all sampling locations except at station 474. At station 474, the concentrations of most elements was very high (170,000 µg/g As and 34,000 µg/g Co) due to the formation of a thick ethyrite concretion (see Figure 4.2.17.2).

Figure 4.2.17.2: Ethyrite concretion at station 474

All of the samples collected in the Nipissing High Grade Tailings were 0 to 5 cm in depth except at station 466 where the creek running through the tailings had cut into a thick deposit of tailing exposing a face approximately one metre thick. Using a hand shovel, the face was cleaned back 10 cm, exposing fresh tailings, and samples were collected at intervals of 60 cm. Concentrations of arsenic, antimony, cobalt, mercury, molybdenum, and nickel showed a distinct profile of increasing concentration with increasing depth (see Figure 4.2.17.3). Arsenic concentrations ranged from 6,400 µg/g at the surface to 24,000 µg/g at 50 to 60 cm. Concentration values between the surface and depth of antimony, arsenic, cobalt, mercury, and molybdenum were 3.3,

3.8, 4.6, 6.9, 22 and 4.3 times respectively. The other elements did not show this profile of increasing concentration wtih increasing depth.

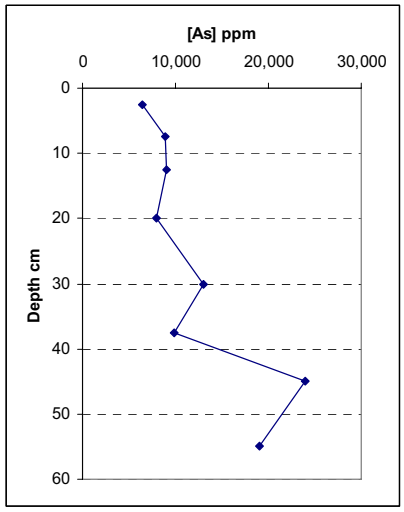


Figure 4.2.17.3: As depth profile

The Nipissing High Grade Tailings site was characterized by medium grained sand tailings with the exception of the areas where concretions had formed. Even though the material was consistent in texture, with the exception of arsenic and cobalt, there was poor correlation between the various elements. The results of the Pearson Correlations analysis (Table B15.b) indicate a large number of significant correlations. However these correlations were driven by the very high numbers found at station 474. Only arsenic and cobalt are significantly correlated when the data from station 474 is removed. This lack of correlation between the elements except for arsenic and cobalt is most likely due to the migration of the arsenic and cobalt through the tailings due to evaporation.

Bio-Accessibility and Speciation Analysis

It should be noted that the MOE method for determining bio-accessibility is not yet accredited and the bio-accessibility results should be confirmed. There is much debate in the scientific literature regarding *in vitro* methods for determining bio-accessibility for metals in soil material. The *in vitro* method used for this project was modified from a method used at United States naval facilities (SBRC, 2000). This method was chosen as it is reproducible, there are good correlations for lead between *in vitro* results using this mehod, and in *in vivo* studies using swine (SBRC, 2000) and it is based on a widely referenced in-vitro method developed by Ruby et al., 1993. Correlations between *in vitro* results using this method and *in vivo* studies for other elements, however, have not been published. At the time of this report, the MOE was in the process of validating its bio-accessibility method and its results via parallel experiments at multiple laboratories.

Metal speciation by sequential extraction and arsenic and mercury availability was only completed on samples from four sampling locations: 162, 175, 179 and 196. These four sampling locations represented a range of metal concentrations (arsenic concentrations for the 250µ soil fraction ranged from 420 to 190,000 µg/g), soil textures (coarse sand to silt) and physical locations. For all samples, the metals speciation exchangeable fraction was very low ranging from 0 to 5% for all elements analyzed (see Table C50). The tailings sample (fine to coarse sand) taken from sampling location 175 had total element concentrations that were low (< 500 µg/g) and the majority of the elements were contained in the residual or non-available fraction. This sampling location was located northeast of the bag house foundations. In the remaining three sample locations, most of the elements were contained in the carbonate, Fe/Mn oxides, and carbonate fractions with the residual fraction containing less than 30%. For sampling location 179 (foundations), the majority of the elements were contained in the organic fraction, while for sampling locations 162 (bag house) and 196 (tailings), element concentrations were generally distributed between the carbonate, Fe/Mn oxides, and carbonate fractions. As shown in Table C50, extractable mercury was low at all four sampling locations, ranging from 1.2 to 10%. The availability of mobile and semi-mobile arsenic was low at sampling location 175 (5%) but ranged between 25 to 42% for the remaining sampling locations. Mobile arsenic ranged between 1 to 3% and semi-mobile arsenic ranged between 22 to 40% at the remaining sampling locations.

These initial metal speciation results show that arsenic, cobalt, copper, nickel, lead, and zinc were, to varying degrees, semi-mobile and existed in multiple chemical forms or species. These elements and mercury, however, were not readily mobile or exchangeable in the four soil textures analyzed. With the exception of sampling station 175, these elements were not present in the residual or nonavailable form. These elements were however present in the carbonate, Fe/Mn oxides, and organic forms. Many factors influence the chemical form or species of metals in soil, with pH and complexing ligands being the dominant factors (Evans, 2004). The species of the metal in soil affects its availability to human or ecological receptors.

4.3 Publicly Accessible Mines, Mills and Tailings

There are a large number of mines, mills and tailings areas within the Cobalt-Coleman Mining Camp area that are not included in the Heritage Silver Trail. A number of these have been fenced off as mine hazards and are not accessible to the public. The following discussion covers the majority of those sites that are readily accessible by the public either on foot or by all-terrain vehicles which are very popular in the Cobalt area. Locations not covered here include the Canadaska Tailings, the Penn Canadian Mill, and the Farr Creek Tailings between the Ontario Ministry of Northern Mines and Development's tailings dam at the north end of Crosswise Lake and the Ministry of Environment's tailings dam on Farr Creek.

4.3.1 Cobalt Reduction Mill (Northern Custom Concentrator, Muggley Concentrator)

The Muggley Concentrators Limited Mill was built in 1907 on the west side of Cobalt Lake at the south end of the Town of Cobalt. The mill was sold to the Northern Custom Concentrators Limited in 1908 and sold again in 1914 to become the Cobalt Reduction Mill which operated until 1932. The mill processed ore from a number of local mines. The mill originally crushed the ore to 20 Mesh (0.85 mm) and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings. Cyanide processing was added in 1915 and a high grade mill was added in 1916. The tailings were deposited at the southwest end of Cobalt Lake. In 1919 these tailings were mined and reprocessed at the Cobalt Reduction and Buffalo Mills. The tailings from the reprocessing at the Cobalt Reduction Mill were put back into Cobalt Lake (the above background information is from Anderson, 1993).

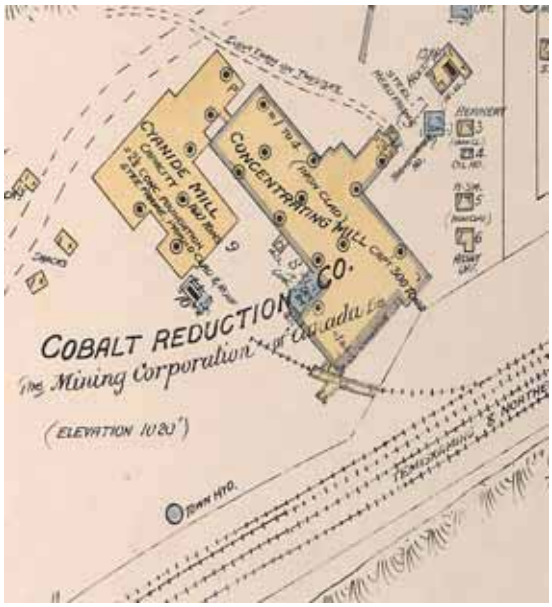


Figure 4.3.1: 1916 Fire Map Cobalt Reduction Mill

The remains of the Cobalt Reduction Mill are located south of Hwy 11B opposite Heritage Silver Trail Sites 1 & 2 on the top of a small hill overlooking the rail line and Cobalt Lake. There is very little left of the mill's foundations. The south and east walls of the Concentrating Mill form a retaining wall on which a furniture store and gravel parking lot is now located (see Figure 4.3.1). The south and east wall of the Cyanide Mill also now form a retaining wall. The top of the Cyanide Mill is mostly waste rock and includes the base of a steel tank at the north end, with approximately 20 to 30 cm of mill waste remaining in the tank base. The area between the base of the hill and the Ontario Northern Railway rail line was covered in medium to coarse tailings. This area of tailings was readily accessible to the public via Townsite Road South and

there were numerous vehicle tire tracks and footprints in the tailings at the time of sampling.

Sampling at Cobalt Reduction Mill was conducted on September 23 and November 17, 2004. Eleven samples were collected from five sampling locations (refer to Map A5.1). Resampling to replace a number of 2004 samples lost by the laboratory was conducted on October 18, 2006. Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples. Two locations were sampled from the within the Cyanide Mill foundations. One location was established at the tank base and the other was located in the waste rock on the foundation floor (stations 479 and 480 respectively) (refer to Figures D296 and D297). The remaining three locations were established in the tailings located between the mill's foundations and the rail line (stations 481 to 483). The sample from station 483 was a large bulk sample collected to provide material for internal QA/QC purposes.

The results of the chemical analysis of the samples collected from Cobalt Reduction Mill are given in Appendix C, Tables C18.a and C18.b. Table C18.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C18.b. Results in Table C18.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.1.1 below.

Table 4.3.1.1: Summary of Chemical Analysis of Soil Samples from the Cobalt Reduction Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	18000	7	360	6	0.7	0.2	8900	92	160	230	35000	62	16000	500	2.5	1.2	120	<0.2	39	7	88	130
5th	18000	8	430	7	0.7	0.2	9000	93	160	230	35000	66	16000	500	2.7	1.2	120	<0.2	44	7	88	130
25th	19000	10	900	9	0.7	0.6	9400	94	320	260	36000	120	17000	530	3.2	1.5	240	<0.2	130	8	90	150
50th	20000	19	1200	10	0.8	0.8	11000	100	600	290	38000	130	18000	550	3.8	1.8	340	1	150	9	92	160
75th	21000	49	4500	49	0.9	1.2	16000	100	1300	700	53000	180	18000	660	12	2	750	1.0	390	17	94	180
95th	32000	140	6500	96	0.9	3	22000	280	1400	980	56000	1800	32000	1200	14	2.7	800	1.0	590	20	120	490
Maximum	32000	140	6800	100	0.9	3	23000	290	1500	990	58000	2000	32000	1200	17	3	830	1.0	660	20	130	490
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
OTR_{98} [3]	2	-	-	-	-	-	0	-	-	-	11	-	9	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	11	11	0	0	4	ns	11	11	11	ns	6	ns	ns	11	1	11	0	11	ns	6	5
Table 2 [5]	ns	7	11	0	0	0	ns	0	11	11	ns	3	ns	ns	4	0	9	0	11	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

All of the 11 soil samples collected from the Cobalt Reduction Mill site exceeded the background and generic *O. Reg. 153/04* soil standards. All samples exceeded both background and generic standards for arsenic, cobalt, copper, and silver (see Table 4.2.17.1). Antimony exceeded the Table 2 generic standard in 64% of the samples, nickel 82%, mercury 33%, and lead in 50% of the samples.

The level and range of concentrations of the majority of elements were at the low end compared to those found at other mills. Arsenic ranged from 360 to 6,800 µg/g, antimony 7 to 140 µg/g, cobalt 160 to 1,500 µg/g, lead 62 to 2,000 µg/g, mercury 2.5 to 17 µg/g, nickel 120 to 830 µg/g, and silver 39 to 660 µg/g.

The spatial distribution of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel and silver at the Cobalt Reduction Mill are presented in Appendix A, Maps A5.2 to A5.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The spatial pattern of arsenic, antimony, cobalt, lead, nickel and silver at the Cobalt Reduction Mill clearly show a difference between the Cyanide Mill's foundations and the tailings area. The concentrations of antimony, arsenic, cobalt, copper, lead, mercury, nickel and silver in the mill's foundations were 3 to 10 times higher than the concentrations found in the tailings. The high lead concentrations were limited to the waste rock fine material at station 480.

The results of the Pearson Correlations analysis (Table B16) indicated a large number of significant correlations. Although a correlation between arsenic and cobalt and nickel at this location is evident in the graphs of these data, the degree of correlation is exaggerated by the two distinct populations of data (refer to Figures B16.1 to B16.6). The much higher concentrations found in the mill's foundations compared to the lower concentrations found in the tailings results in a false correlation between arsenic and antimony, lead, mercury and silver.

4.3.2 Buffalo Low Grade Mill, High Grade Mill and Tailings

The Buffalo Mills were located on the Buffalo Mines Limited property in the SW¼ of the S½ of Lot 6, Concession VI, Coleman Township. The Buffalo Low Grade Mill was the second concentrator to be built on the site in September 1907. The Buffalo High Grade Mill and Refinery was built just east of the Low Grade Mill in November, 1912 (refer to Figure 4.3.2). The mills were sold in 1920 and finally closed in 1923. The Low Grade Mill was re-opened briefly in 1935 and in the 1950's to re-treat tailings. The Low Grade Mill's foundations have been fenced off as a mine hazard and the majority of the High Grade Mill's foundations have been covered over with clay top soil.

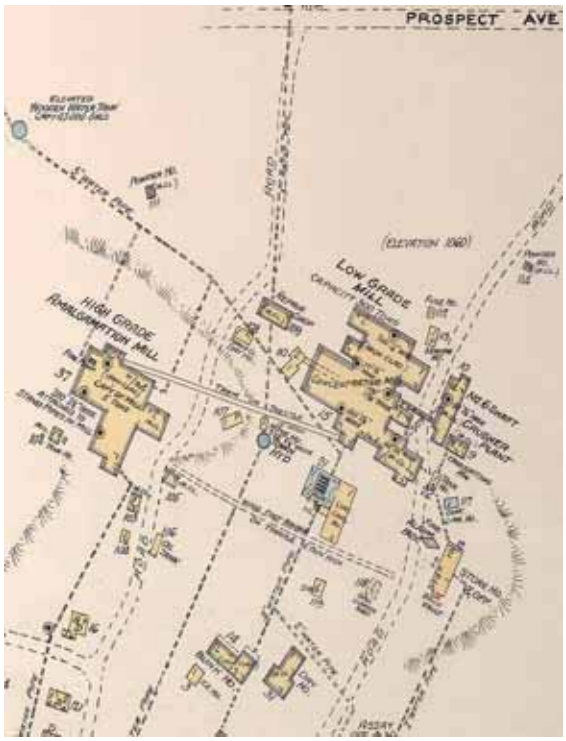


Figure 4.3.2: 1916 Fire Map of the Buffalo Mills

Tailings from the mills were originally deposited in a long, narrow valley extending northeast from the mills. The tailings were mined-out and re-treated in 1920s. The tailings have migrated north over time to their present location at Prospect Street near the Coniagas open pit. The tailings were covered with gravel or waste rock and approximately 6" of soil. The Cobalt Municipal Trailer Park just north of the mills was built on the tailings. The only exposed tailings occur beside the Low Grade Mill. They consist of coarser sand tailings at the north end immediately adjacent the Low Grade Mill and fine slime tailings to the south (the above background information is from Anderson, 1993).

At the time of the sampling, the site consisted of the Buffalo Low Grade Mill and the Buffalo High Grade Mill foundations with an area of tailings in between. The High Grade Mill was located on the west side at the top of a hill. The majority of the High Grade Mill's foundations were covered in clay topsoil sometime in the 1990's and just a portion of the eastern foundation

wall was left exposed. The soil was largely covered with grass and herbaceous vegetation at the time of sampling. With the exception of a small part of the western edge, the Buffalo Low Grade Mill foundations were fenced off as a mine hazard and were not accessible. The tailings consisted of two types: at the north end, the tailings by the Buffalo Low Grade Mill were a medium to coarse grained sand while at the south end, the tailings were much finer grained and had Baltic rush growing on them. The area with coarse grained tailings was partially covered with yard waste compost and a local resident was trying to get trees to grow in this area.

Two locations in the tailings area were sampled on October 26, 2003 (stations 213 and 214). The major sampling effort was conducted on September 2, 20, 21 and 23, 2004. A total of eighty-seven samples were collected from thirty sampling locations (refer to Maps A18.1). Because of the varied nature of the site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples. Only seven locations were established in the tailings area, with the bulk of the sampling being conducted around the mill's foundations and the base of the hill below the foundations. Many of the sampling locations around the mill were selected based on the high concentrations of mercury found using the portable XRF instrument.

The results of the chemical analysis of the samples collected from Buffalo High Grade Mill and Tailings are given in Appendix C, Tables C19.a and C19.b. Table C19.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C19.b. Results in Table C19.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.2.1 below.

Table 4.3.2.1: Summary of Chemical Analysis of Soil Samples from the Buffalo High Grade Mill and Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	6300	1.0	4	8	0.2	0.2	1600	23	17	16	9100	12	1500	220	0.32	0.3	42	0.2	5	7	21	63
5th	11000	2.2	15	10	0.4	0.2	2100	42	19	33	22000	15	4100	350	2.5	0.3	45	0.2	5	9	37	68
25th	14000	24	1800	52	0.6	0.4	3200	57	300	190	28000	230	5400	440	26	0.57	180	0.3	90	16	42	210
50th	17000	120	4900	87	0.8	2.0	4700	66	760	630	32000	530	6800	550	450	1.5	350	1.0	380	29	49	470
75th	21000	180	15000	140	1.0	3	12000	85	2500	980	40000	1300	16000	660	2600	4	910	1.0	820	48	60	910
95th	28000	2800	150000	160	1.5	12	25000	110	25000	4000	69000	11000	19000	830	23000	29	9400	1.0	4100	77	100	3300
Maximum	30000	4000	180000	290	1.9	53	28000	130	27000	4900	74000	12000	20000	1100	26000	38	9900	1.2	5100	240	110	4000
Stations [1]	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Samples [2]	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87	87	77	87	87	87	87
OTR_{98} [3]	5	-	-	-	-	-	0	-	-	-	39	-	17	0	-	-	-	-	-	5	-	-
Table 1 [4]	ns	86	82	1	8	56	ns	34	81	70	ns	68	ns	ns	87	33	84	0	87	ns	11	71
Table 2 [5]	ns	69	82	0	8	3	ns	0	73	64	ns	66	ns	ns	71	0	66	0	70	ns	0	31

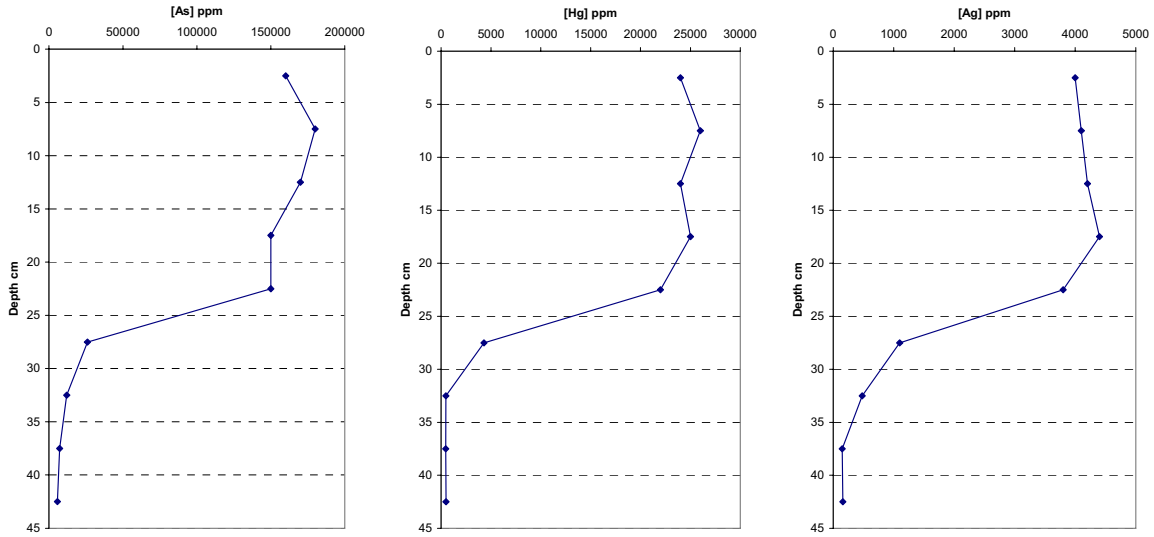
[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

With the exception of the areas characterized by dee p clean clay topsoil (stations 449, 450 and 451), *O. Reg. 153-04 Table 1 Background Standards* were exceeded at all locations for antimony, arsenic, mercury, nickel, and silver. Arsenic *Table 2 Generic Standards* were also exceeded at all of these locations. Antimony exceeded the *Table 2 Generic Standards* in 79% of the samples, cobalt 84%, copper 74%, lead 76%, mercury 82%, nickel 76%, silver 80%, and zinc 36%.

Arsenic concentrations ranged from a low of 4 µg/g in the clean clay topsoil to 180,000 µg/g in the northwest corner of the upper mill foundations with a median concentration of 4,900 µg/g. Antimony ranged from 1.0 to 4,000 µg/g, cobalt from 17 to 27,000 µg/g, lead from 12 to 12,000 µg/g, nickel from 42 to 9,900 µg/g and silver from 5 to 5,100 µg/g. Mercury concentrations ranged from 0.32 to 26,000 µg/g, with a median concentration of 450 µg/g. These were the highest median mercury concentrations found at any of the mills in the Cobalt-Coleman Mining Camp.

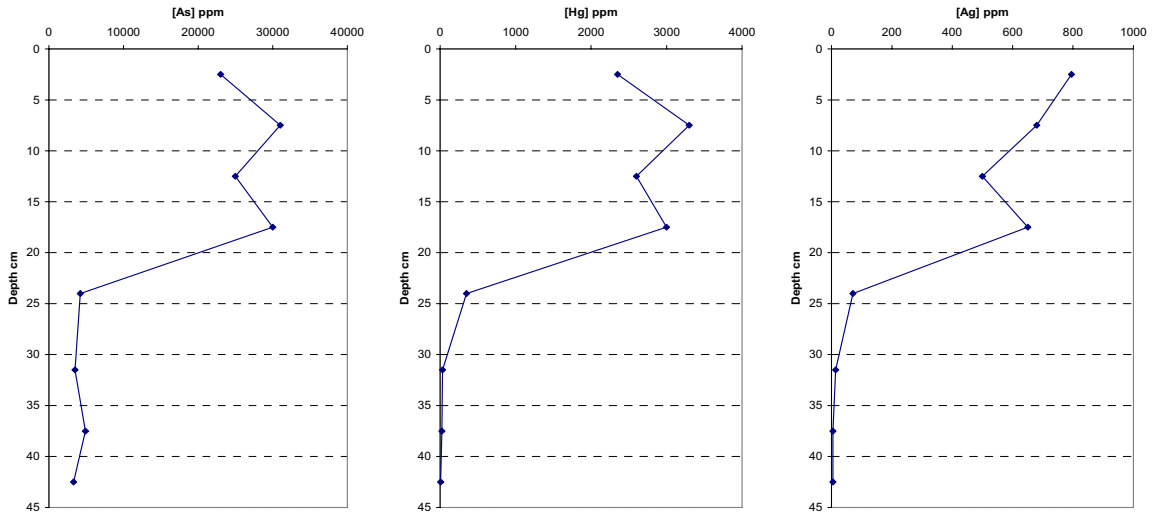
Arsenic, antimony, cobalt, lead, mercury, nickel, and silver have essentially the same spatial distribution over the Buffalo High Grade Mill and Tailings, (refer to Maps A18.2 to A18.8). The highest concentration of arsenic, mercury and other metals was found at station 438 in the northwest corner of the upper High Grade Mill foundations. This is a small area of approximately 20 square metres of bare soil. The high concentrations of arsenic and mercury extend down the hill in a drainage course located on the north side of the mill to the lower portion of the hill between an old road and the tailings. High arsenic and mercury concentrations were also found at station 454 and 455 around some concrete foundations at the south end of the mill site on the lower portions of the hill. The mercury from this second location appeared to have migrated down the hill and onto the tailings.

Depth profile sampling was conducted at three locations, station 213 in the fine tailings, station 438 located in the northwest corner of the upper mill foundations, and station 462 located at the base of the hill, where a local resident had exposed the soil profile while building a temporary loading ramp. Extremely high concentrations of arsenic, mercury and other metals were found at Station 438. These extremely high concentrations were limited to the first 25 cm with concentrations dropping rapidly below 25 cm (refer to Figures 4.3.2.2 to 4.3.2.4).



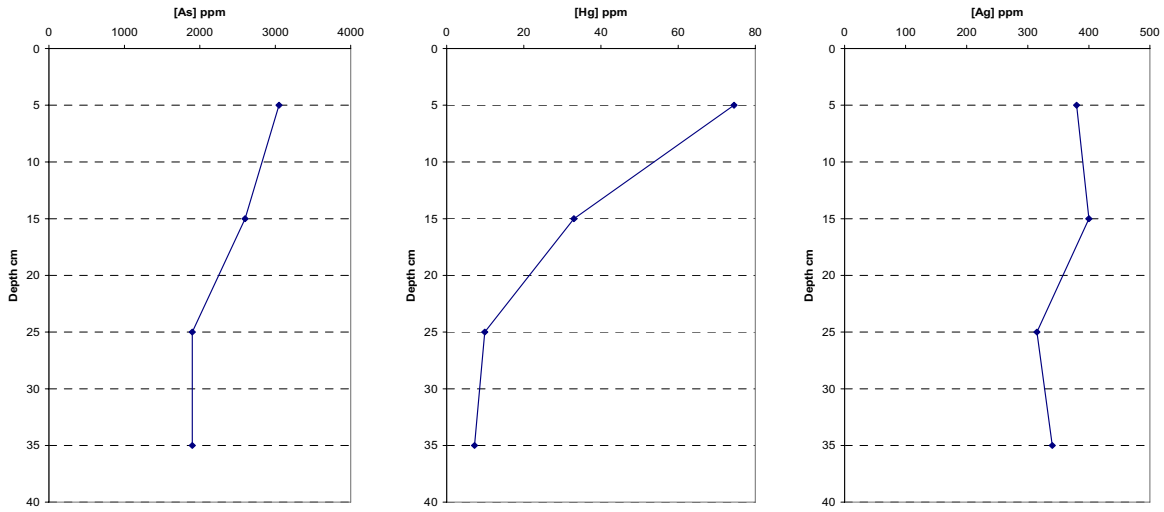
Figures 4.3.2.2 to 4.3.2.4: As, Hg and Ag profiles at Buffalo High Grade Mill station 438.

A very similar soil profile was observed at the temporary loading dock site with high concentrations of arsenic, mercury and other metals limited to the first 20 cm of the soil profile. Below 20cm, concentrations dropped very rapidly over a 5 cm interval (refer to Figures 4.3.2.5 to 4.3.2.7).



Figures 4.3.2.5 to 4.3.2.7: As, Hg and Ag profiles at Buffalo High Grade Mill station 462.

The soil profiles in the fine tailings area at station 213 show a distinctly different pattern. The concentrations of antimony, arsenic, cobalt, copper, lead, nickel, and silver decreased marginally with depth by a factor of approximately 2. The concentration of mercury decreased rapidly with depth by a factor of 10 at 20cm. The mercury was largely confined to the upper 10cm of the tailings. This suggests that the mercury observed in the tailings was the result of mercury being washed down the hill from the High Grade Mill into the tailings area. This is consistent with the pattern of mercury observed in the drainage channel located on the north side of the mill foundations.



Figures 4.3.2.8 to 4.3.2.10: As, Hg and Ag profiles at Buffalo High Grade Mill station 213.

The results of the Pearson Correlations analysis indicate strong correlations between arsenic, antimony, cobalt, copper, mercury, nickel and silver. Examination of the graphs of these relationships shows a correlation of increasing concentrations of these metals with increasing concentrations of arsenic however the degree of the correlation is being forced by the very high concentrations found in the depth profile samples at station 438. The actual correlations for the whole site are not as significant as indicated with more scatter at the lower concentrations.

4.3.3 Trethway Mill and Tailings

The Trethway Silver Cobalt Mining Company Limited operated a mill located on the SE¼ of the N½ of Lot 6, Concession VII, Coleman Township from 1910 to 1920 when the property was sold and the mill closed. There is no record of when the mill was demolished. The mill crushed the ore to 20 Mesh (0.85 mm) and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings. The tailings from the mill were contained in a valley at the base of the mill by an earthen dam at the valley mouth on the shores of Lake Sasaginaga.

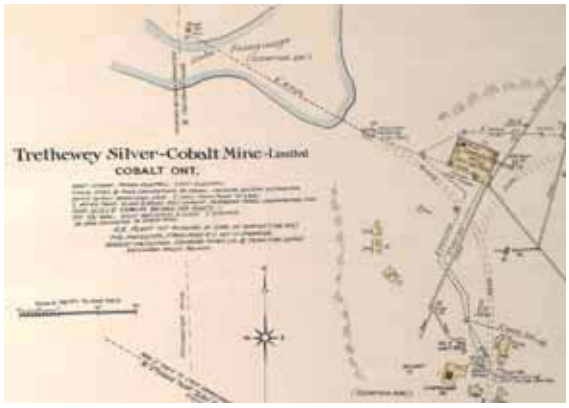


Figure 4.3.3:1916 Fire Insurance Map Tretheway Mill

Three smaller dams were located at the north end of the valley. Most of the tailings were removed in 1975 for reprocessing off-site. All of the tailings were not removed at that time as it was feared that Lake Sasaginaga may break through the dam. The tailings cover an area of approximately 1.4 hectares (the above background information is from Anderson, 1993).

At the time of sampling, the Trethway Mill consisted of concrete mill foundations that were overgrown with tree saplings. There was only one small area of mill waste within the mill foundation itself. The general lack of mill wastes in the foundations explained the presence of the trees. This was the only mill site in the Cobalt-Coleman Mining Camp where such tree growth was observed. An old road constructed of waste rock and possibly mill waste ran along the base of the mill. To the east of the mill there was an area of limited vegetation growth and what appeared to be mill waste mixed with wood fibres. The tailings from the mill were located in a small valley that ran in a northeast to southwest direction. To the southwest the tailings had migrated into an arm of Lake Sasaginaga, near the mouth of the Sasaginaga Creek. These tailings were kept from entering the main body of the lake by a tailings dam. To the northeast the tailings ran down the valley towards the Hudson Bay Tailings located in Sasaginaga Creek. There were the remains of a wooden tailings dam at the north end of the main tailings area. Tailings had migrated past the dam. There was a shallow pond in the middle of the main tailings area in the valley.

Sampling at Trethway Mill and Tailings was conducted on July 12 and 13, 2005. Six samples were collected f rom three sampling locations at the mill and fifty-six samples were collected from 10 locations within the tailings area (refer to Maps A20.1). Because of the varied nature of the mill site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples. Sampling areas were fixed at 5 x 5 m in the tailings and all sampling was performed with cores at 10 cm increments to a depth of 30 cm.

The results of the chemical analysis of the samples collected from Trethway Mill and Tailings are given in Appendix C, Tables C20.a and C20.b. Table C20.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont.*

Reg. 153-04 are given in Table C20.b. Results in Table C20.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Trethway Mill and Trethway Tailings are given below in Table 4.3.3.1 and 4.3.3.1 respectively.

Table 4.3.3.1: Summary of Chemical Analysis of Soil Samples from the Trethway Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	13000	28	4500	100	1.0	2.6	3200	50	900	740	31000	640	6200	350	10.0	1.7	280	1.0	750	10	44	710
25th	13000	58	5200	120	1.0	4	4000	56	1200	820	35000	710	8400	400	11	3.2	350	1.0	840	11	52	940
50th	14000	76	6300	130	1.1	4	7300	58	1400	1500	38000	920	10000	490	31	4	410	1.0	1500	16	56	1600
75th	18000	89	6600	140	1.1	5	8600	78	1500	2800	42000	2000	14000	520	57	5	440	1.0	2400	50	77	1800
Maximum	19000	93	15000	210	1.5	5	9000	87	1900	3100	46000	2800	15000	570	66	5.2	450	1	2600	71	85	2200
Stations [1]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Samples [2]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	5	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	6	6	0	1	6	ns	2	6	6	ns	6	ns	ns	6	5	6	0	6	ns	0	6
Table 2 [5]	ns	6	6	0	1	0	ns	0	6	6	ns	6	ns	ns	5	0	6	0	6	ns	0	6

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.3.3.2: Summary of Chemical Analysis of Soil Samples from the Trethway Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	16000	3	260	3	0.8	0.2	2400	77	87	160	31000	47	13000	380	1.1	0.4	64	<0.2	52	2	68	57
5th	17000	5	310	3	0.9	0.2	3000	81	110	170	32000	58	14000	390	1.3	0.6	69	<0.2	55	3	72	72
25th	17000	7	390	4	0.9	0.5	5100	84	140	190	32000	78	14000	430	2.0	0.8	79	1.0	89	5	76	92
50th	18000	10	460	4	1.0	0.8	6800	86	160	240	34000	120	15000	460	2.3	1.0	92	1.0	100	6	80	120
75th	19000	15	530	5	1.1	1.0	8300	88	190	280	36000	200	16000	490	3.2	1.3	110	1.0	150	7	88	280
95th	20000	36	800	7	1.2	1.4	10000	95	230	360	39000	300	16000	560	5.4	1.7	150	1.0	220	9	92	370
Maximum	22000	47	1000	11	1.3	2.0	13000	100	320	440	41000	360	18000	600	8.6	2.2	160	1.0	450	11	96	460
Stations [1]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Samples [2]	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56	56
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	30	-	3	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	56	56	0	1	12	ns	56	56	56	ns	26	ns	ns	56	0	56	0	56	ns	8	24
Table 2 [5]	ns	17	56	0	1	0	ns	0	56	31	ns	13	ns	ns	0	0	2	0	56	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Although the Trethway Mill had little in the way of mill wastes present, all of the samples from the three sampling locations exceeded both the *O. Reg. 153-04 Table 1 Background Standards* and *Table 2 Generic Standards* for antimony, arsenic, cobalt, copper, lead, mercury, nickel, silver, and zinc. In contrast, only arsenic, cobalt, and silver exceeded both Table 1 and Table 2 standards in all the tailings samples. In the tailings, antimony exceeded the Table 2 standards 30% of the time, copper 55%, lead 23%, mercury 0%, nickel 4%, and zinc 0%.

At the mill site, arsenic and the other metal concentrations were moderately high compared to the very high concentrations found at the high grade mills. Arsenic concentrations at the mill ranged from 4,500 to 15,000 µg/g. The concentration of arsenic in the tailings was similar to other coarse grained tailings but much lower than the arsenic concentrations typically found in fine grained tailings. Arsenic concentrations in the tailings ranged from 260 to 1,000 µg/g with a median concentration of 460 µg/g. Concentrations of the other metals in the tailings were also at the low end of the range of those found in tailings within the Cobalt-Coleman Mining Camp.

The spatial distribution of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Trewathy Mill and Tailings are presented in Appendix A, Maps A20.2 to A20.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger

and darker the dot the higher the concentration. A pattern of spatial distribution could not be determined due to the relatively clean nature of the mill foundations and the small number of sampling locations. The concentrations of arsenic and metals at the three locations sampled (old road base, mill waste on the concrete floor of the foundation, and the mill waste to the east of the upper levels) had similar concentrations. The spatial distribution of arsenic and the other metals in the tailings was very even. This was expected given the small range in concentrations found in the tailings. There was also no significant pattern found in the concentrations of arsenic or other metals with depth in the tailing samples.

The results of the Pearson Correlation analysis show no significant correlations between arsenic and any of the other elements in both the mill and tailing samples. The graphs of the relationships between arsenic and antimony, cobalt, lead, mercury, nickel, and silver show a general scatter in the data.

4.3.4 Hudson Bay Tailings

The Hudson Bay Mill, located on the N½ of the N ½ of Lot 7, Concession VI, Coleman Township was built in 1910. The mine and mill were closed in 1920. The Hudson Bay Mill foundations and surrounding property have been fenced off. The mill crushed the ore to 20 Mesh (0.85 mm) and the material was concentrated using a wet gravity process resulting in largely coarse sandy tailings.

The tailings from the mill were deposited directly at the base of the mill into the Sasaginaga Creek valley and allowed to wash down the creek to the Chambers-Ferland tailings area. In 1948 some of the remaining tailings and waste rock were removed for reprocessing. The remaining tailings cover approximately 2.1 hectares of the upper Sasaginaga Creek valley (the above background information is from Anderson, 1993.)

At the time of sampling, the Hudson Bay Mill was fenced off as a mine hazard and was not accessible for sampling. The tailings from the Hudson Bay Mill and possibly some tailings from the Trethway Mill are located on the south side of Sasaginaga Creek and are readily accessible by vehicles. The tailings consisted largely of mounds of medium grained tailings with some waste rock mixed in. Arsenic tolerant Baltic rush was growing in the lower areas while the mounded tailings had little or no vegetation growing on them (refer to Figures D323 to D325).

Sampling at Hudson Bay Tailings was conducted on July 16, 2005. Sixteen samples were collected from three sampling locations within the tailings area (refer to Maps A20.1). Each sample location was 5 x 5 m in area and was sampled using a corer at 10 cm increments to either 20 or 30 cm depth. All samples were composites of a minimum of 10 cores.

The results of the chemical analysis of the samples collected from Hudson Bay Mill are given in Appendix C, Tables C21.a and C21.b. Table C21.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C21.b. Results in Table C21.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.4.1 below.

Table 4.3.4.1: Summary of Chemical Analysis of Soil Samples from the Hudson Bay Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	17000	3	310	3	1.0	0.2	4300	82	130	180	32000	35	14000	420	1.4	<0.3	83	1.0	110	4	74	65
5th	17000	4	340	3	1.0	0.2	4700	83	130	200	32000	40	14000	430	1.6	0.4	84	1.0	120	5	75	66
25th	18000	6	380	4	1.1	0.2	5800	86	160	220	33000	48	15000	440	2.3	0.6	93	1.0	130	5	75	71
50th	18000	8	540	4	1.1	0.2	8100	88	180	260	34000	50	15000	450	3.4	0.6	98	1.0	180	7	78	74
75th	19000	8	630	4	1.2	0.5	9200	89	190	270	34000	54	15000	460	4.7	0.7	100	1.0	200	8	80	80
95th	20000	10	1000	6	1.2	0.9	9800	97	320	330	36000	68	16000	520	5.8	0.8	140	1.0	220	10	85	84
Maximum	21000	11	1000	6	1.2	0.9	10000	100	370	340	38000	84	17000	530	6.0	0.8	150	1.0	230	10	88	87
Stations [1]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Samples [2]	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	8	-	1	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	16	16	0	0	0	ns	16	16	16	ns	0	ns	ns	16	0	16	0	16	ns	0	0
Table 2 [5]	ns	0	16	0	0	0	ns	0	16	10	ns	0	ns	ns	0	0	0	0	16	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the Hudson Bay Tailings, only arsenic, cobalt, and silver exceeded both the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all sixteen samples that were collected. Copper exceeded the Table 2 standards in 63% of the samples. All sixteen samples were above the *Table 1 Background Standards* for antimony, chromium, mercury, and nickel however none exceed the Table 2 *Generic Standards* for these elements.

Arsenic and metal concentrations in the Hudson Bay Tailings were at the lower end of the range found in tailings within the Cobalt-Coleman Mining Camp. Arsenic concentrations ranged from 310 to 1000 µg/g with a median concentration of 540 µg/g.

There was no significant pattern of arsenic and other metals both spatially and with depth between the three sampling locations as the range in concentrations was small. The lowest concentrations were found at station 513 to the east where Baltic rush was observed growing. The highest concentrations were found in the 0 to 10 cm samples collected at station 515. There was more fine tailings material at this location near the surface than at the other locations. The lack of vegetation, observed at stations 514 and 515, in particular Baltic rush, was not due to arsenic (Baltic rush will grow in arsenic concentrations up to 2000 µg/g) but rather a lack of water. The tailings at station 514 and 515 were coarse and at higher elevation and thus bettered drained in comparison to station 513.

The results of the Pearson Correlation analysis show a high degree of correlation between arsenic and barium, calcium, cobalt, iron, manganese, nickel, strontium and vanadium. This, in addition to the good correlations of aluminum with most of the elements, indicates that the tailings are of the same origin, from both a geological and milling process perspective.

4.3.5 Coniagas Mill and Tailings

The Coniagas Mill was located in the NE¼ of the S½ of Lot 7, Concession VI, Coleman Township (refer to Figure 4.3.5). The Coniagas Mill ran from September 1907 to 1924 when it closed after a fire destroyed most of the buildings on the property. The mill crushed the ore to 20 Mesh (0.85 mm) and the material was concentrated using a wet gravity process resulting in largely coarse sand tailings.

Coniagas Mines did not practice good tailings management. Tailings were originally released from the mill and allowed to flow unchecked down the hill encroaching on and destroying residential and commercial buildings. In 1915 the tailings were separated into coarse sand stored in the original containment area and fine slimes stored in a depression (now part of the Cobalt Public School) for future re-processing. Waste from the re-processed tailings was transported by flume to the Chambers-Ferland area. In 1977 the remaining tailings down to the base layer of fine-grained tails and clay were transported off-site for processing (the above background information is from Anderson, 1993).

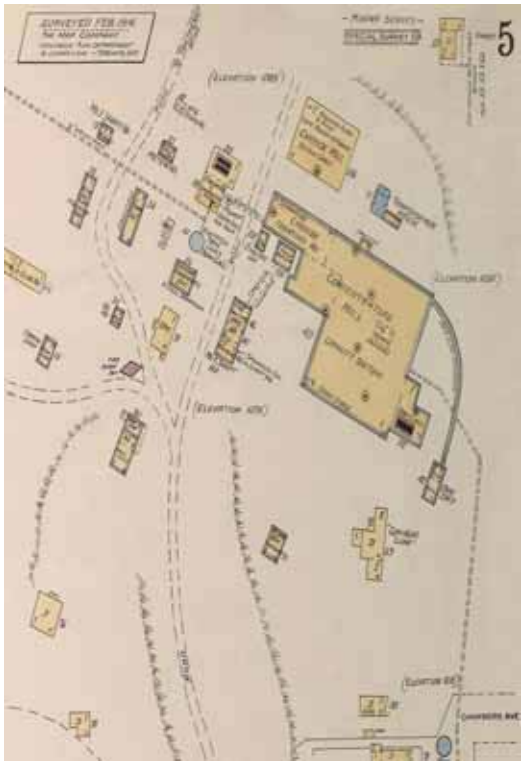


Figure 4.3.5:1916 Map of the Coniagas Mill

Although the Coniagas Mill foundations and surrounding property have been fenced off as mine hazards, the tailings have migrated through the fence at the bottom of the hill and along the southern boundary of the property adjacent to the Father Les Costello Memorial Arena and residential properties. The tailings along the north end of Chambers Avenue are used by local residents for parking (station 779). An area on the side of the hill bordering the west side of the parking area was comprised of cinder/slag like material (station 780).

Sampling of the tailings from the Coniagas Mill was conducted on July 25, 2006. Eighteen samples were collected from six locations (Map A37.1 in the upper left quadrat). Samples were taken with a corer at multiple depths from 5 x 5 m areas. All samples were composites of a minimum of 10 cores or trowel samples.

The results of the chemical analysis of the samples collected from Coniagas Tailings are given in Appendix C, Tables C22.a and C22.b. Table C22.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for parameters not captured under *Ont. Reg. 153-04* are given in Table C22.b. Results in Table C22.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.5.1 below.

Table 4.3.5.1: Summary of Chemical Analysis of Soil Samples from the Coniagas Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	8600	0.5	82	3	0.3	0.6	3700	35	30	62	15000	24	6600	290	0.38	<0.3	34	<0.2	12	5	31	44
5th	9000	0.6	85	3	0.4	0.6	4100	37	30	63	16000	28	6800	320	0.45	<0.3	34	<0.2	15	5	32	46
25th	13000	10	250	5	0.9	0.8	5800	52	91	170	31000	46	13000	390	1.8	0.6	100	<0.2	110	6	56	82
50th	17000	16	360	8	1.0	1.0	8300	77	110	280	32000	57	14000	500	2.4	0.9	120	<0.2	160	8	75	90
75th	18000	26	560	24	1.4	1.2	9600	80	150	320	34000	80	15000	520	4.0	1.2	150	<0.2	230	27	82	99
95th	19000	51	1000	180	1.7	1.2	32000	84	260	370	36000	410	18000	550	6.9	2	180	0.9	500	150	84	260
Maximum	19000	88	1300	240	2.0	1.3	33000	86	290	390	39000	690	19000	560	14	3	210	1.3	880	200	85	400
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	8	-	2	0	-	-	-	-	-	3	-	-
Table 1 [4]	ns	16	18	1	6	7	ns	12	18	16	ns	3	ns	ns	18	1	16	0	18	ns	0	3
Table 2 [5]	ns	11	18	0	6	0	ns	0	16	12	ns	3	ns	ns	1	0	3	0	16	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all 18 samples collected from this area. Antimony exceeded the Table 2 standards in 61% of the samples, cobalt in 89%, copper in 67%, lead in 17%, nickel in 17%, and silver in 89% of the samples. In the Coniagas tailings, arsenic concentration ranged from 82 to 760 µg/g with a median concentration of 330 µg/g. The concentrations of arsenic and other metals in the tailings material fell within the low end of the range of arsenic found in tailings within the Cobalt-Coleman Mining Camp and were typical of the coarse grained tailings found in other areas of the camp. Arsenic and metal concentrations in the cinder/slag like material were considerably higher with arsenic concentrations ranging from 880 to 1,300 µg/g. All three of the exceedances of the Table 2 standards for lead were found in the cinder/slag like material.

There was no spatial pattern in the concentrations of arsenic and metals in the tailings at the Coniagas Mill with the exception of the higher arsenic and metal concentrations in the cinder/slag like material at station 780. This is largely due to the small range in concentrations observed in the tailings. There was also no consistent pattern of increasing or decreasing concentrations with depth.

The results of the Pearson Correlations analysis showed a large number of correlations between the elements. Arsenic was significantly correlated with antimony, beryllium, cobalt, lead, molybdenum, nickel, selenium, strontium, and zinc. The numbers of correlations are an indication that the material sampled in this area originated from the same ore body and milling process.

4.3.6 O'Brien (Deer Horn) Mill

Silver was discovered on the S½ of Lot 4, Concession VI, Coleman Township in 1903. The property was purchased by M.M. O'Brien Limited and became the longest producing mine in the Cobalt camp, running continuously until 1937. In 1909, a 30 stamp combined cyanide and wet treatment concentrator was built. In 1913 the mill's output was increased to 140 tons per day. The tailings from the mill were run through an underground pipeline to the bottom of the hill and deposited in the mouth of Peterson Creek where it emptied into Mill Creek. On September 4, 1922 the mill was destroyed by a fire.

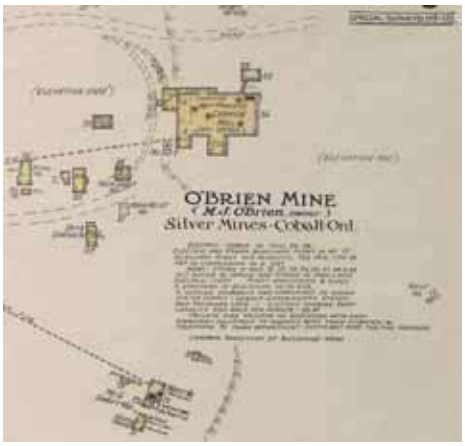


Figure 4.3.6: 1916 Fire Map O'Brien Mill

In 1952, the Nipissing Mining Company Limited and M.M. O'Brien merged and a new 100 ton gravity and flotation mill was built on the foundations of the original mill in 1954. The property was sold in 1959 and became known as the Deer Horn Mill. The mill did not operate after 1970 and was torn down in the 1990's (the above background information is from Anderson, 1993).

Sampling at the O'Brien Mill was conducted on July 13 and 14, 2005. Thirty seven samples were collected from sixteen sampling locations at the mill (refer to Maps A21.1). Because of the varied nature of the mill site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

The results of the chemical analysis of the samples collected from the O'Brien Mill are given in Appendix C, Tables C23.a and C23.b. Table C23.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C23.b. Results in Table C23.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.6.1 below.

Table 4.3.6.1: Summary of Chemical Analysis of Soil Samples from the Obrien (Deerhorn) Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	11000	2.4	1900	9	0.3	0.72	2500	48	220	340	20000	340	3900	220	1.7	0.44	130	1.0	140	9	39	320
5th	12000	14	2300	9	0.5	1.3	5000	61	430	640	30000	360	7200	320	3.0	1.4	200	1.0	180	11	47	370
25th	16000	43	4000	27	0.8	3.7	12000	72	750	1200	42000	740	14000	520	8.5	3	290	1.0	470	16	69	1100
50th	20000	180	6300	33	0.8	6	14000	99	1300	2300	48000	1800	18000	650	14	5	660	1.0	1200	20	89	2100
75th	24000	380	9700	59	1.0	9.2	18000	120	1900	3900	55000	3300	21000	890	23	8	900	1.0	1800	36	110	2900
95th	26000	580	15000	160	1.6	23	44000	140	3100	10000	69000	6400	27000	1100	34	11	1500	2.6	2900	150	140	13000
Maximum	28000	650	40000	210	3.4	37	52000	170	7100	14000	100000	12000	29000	1200	130	18	3600	4	6900	240	150	14000
Stations [1]	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Samples [2]	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37	37
OTR_{98} [3]	2	-	-	-	-	-	0	-	-	-	34	-	24	0	-	-	-	-	-	5	-	-
Table 1 [4]	ns	37	37	0	4	35	ns	29	37	37	ns	37	ns	ns	37	30	37	4	37	ns	15	37
Table 2 [5]	ns	36	37	0	4	8	ns	0	37	37	ns	37	ns	ns	25	0	36	0	37	ns	0	30

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, the O'Brien Mill site consisted of concrete foundations and waste rock located on the west and east sides of the mill. The lower foundations were largely free of mill waste, with the bulk of the mill waste found in the upper levels of the foundations and along the north side of the foundations where the waste from the upper foundations had migrated by erosion.

Arsenic, cobalt, copper, lead, and silver exceeded both the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic Soil* standards in all 37 samples collected at the mill site. Antimony exceeded the Table 2 standards in 97% of the samples, mercury in 68%, and nickel in 97% of the samples. Arsenic concentrations ranged from 1,900 to 40,000 µg/g with a median concentration of 6,300 µg/g. Concentrations of antimony ranged from 2.4 to 650 µg/g, lead from 340 to 12,000 µg/g and mercury from 1.7 to 130 µg/g.

The spatial distribution of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the O'Brien Mill are presented in Appendix A, Maps A21.2 to A21.8 respectively. The

concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. Other than a tendency for the higher concentrations to be found in the mill waste located in the upper levels of the foundations, there was no significant spatial pattern for arsenic and other metals at the O'Brien Mill site. An area of note is the concentrations of arsenic and metals found in the waste rock fine material at stations 566 and 567. The concentration of arsenic and metals in this waste rock fine material were some of the highest found in the Cobalt-Coleman Mining Camp. The concentrations found in the waste rock material were not significantly different from the majority of the mill waste material. Arsenic concentrations in the waste rock ranged from 6,200 to 17,000 µg/g and lead concentrations ranged from 3,300 to 11,000 µg/g. There was no evidence of the waste rock being contaminated with mill waste.

The results of the Pearson Correlations analysis showed few correlations between any of the elements at the O'Brien Mill. Arsenic was only correlated with cobalt and mercury and the mercury correlation was largely due to one data point driving the correlation.

4.3.7 Silver Cliff (Pilliner, Ausic, United Cobalt) Mill

The Silver Cliff Mill was located in the SE ¼ of the S ½ of Lot 3, Concession VI, Coleman Township on the western shore north end of Crosswise Lake. A 100 ton per day mill was built in 1910 and only operated for two years. The tailings from the mill were deposited into the lake and later reprocessed at the King Edward Mill. The mill was re-conditioned and re-opened in 1944 as the Ausic Mill. The mill operated intermittently from 1944 till 1969 (the above background information is from Anderson, 1993).

Sampling at the Silver Cliff Mill was conducted on July 15 and 16, 2005. Twelve samples were collected from four sampling locations at the mill (refer to Map A24.1). Because of the varied nature of the mill site, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples.

At the time of the sampling, the Silver Cliff Mill consisted of a large lower foundation with a concrete floor that was largely bare. Some mill waste had eroded from the upper level and had Baltic rush growing on it. There was a 4 x 4 m area in the centre of the floor with distinctly dark soil that had no vegetation growing on it (station 511). XRF readings taken at this location indicated very high concentrations of arsenic and metals. The remains of a bonfire pit was observed in the lower foundations. The upper foundations had a large amount of fine grained mill waste around the concrete pillars. Baltic rush was also growing in this material.

The results of the chemical analysis of the samples collected from Silver Cliff Mill are given in Appendix C, Tables C24.a and C24.b. Table C24.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C24.b. Results in Table C24.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.7.1 below.

Table 4.3.7.1: Summary of Chemical Analysis of Soil Samples from the Silver Cliff Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	15000	4	1000	8	0.9	1.0	6100	34	330	190	32000	650	7100	260	2.2	1.3	93	<0.2	95	7	54	360
25th	17000	18	2000	9	1.0	1.4	13000	69	360	630	33000	690	16000	440	4.4	1.6	130	<0.2	110	9	91	460
50th	19000	21	2800	9	1.1	1.8	14000	78	410	680	35000	860	19000	480	5.0	2.0	140	0.6	120	9	98	490
75th	20000	26	3200	13	1.2	2.4	15000	79	440	790	37000	2000	19000	510	6.7	3	140	1.2	130	11	100	790
Maximum	25000	70	46000	290	1.4	6	29000	99	14000	3900	60000	17000	24000	710	20	18	2200	2.2	1000	140	130	1600
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	8	-	8	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	12	12	2	2	10	ns	8	12	12	ns	12	ns	ns	12	4	12	1	12	ns	8	12
Table 2 [5]	ns	10	12	0	2	0	ns	0	12	11	ns	12	ns	ns	2	0	3	0	12	ns	0	4

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic, cobalt, lead and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all 12 samples collected at the mill site. Antimony exceeded the Table 2 standards in 83% of the samples, copper in 92%, mercury in 17%, and nickel in 25% of the samples. Arsenic concentrations ranged from 1,000 to 3,300 µg/g with a median concentration of 2,600 µg/g (excluding the results from station 511). Arsenic and metal concentrations at station 511 were significantly higher with arsenic ranging from 44,000 to 46,000 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Silver Cliff Mill are presented in Appendix A, Maps A24.2 to A24.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. With the exception of lead, the spatial pattern at the mill consisted of very high concentrations at the one sampling site in the lower foundations of the mill and similar concentrations at the remaining three sampling locations. The pattern for lead differed in that the high concentrations of lead were found on the trail leading up to the upper foundations at station 502.

The results of the Pearson Correlation analysis indicated a large number of correlations between the elements. These correlations however were the result of the small number of samples and the large difference in concentrations between station 511 and the other three stations. Removing station 511 from the Pearson Correlation analysis yielded few correlations.

4.3.8 Crosswise Lake Tailings & Mines

The Mile 104 Mill, the O'Brien Mill, the Colonial Mill, the Silver Cliff Mill and the King Edward Mill all discharged their tailings directly into Crosswise Lake. Tailings from the Beaver Mill migrated into the south end of Crosswise Lake via Kirk Creek which drains Kirk Lake (the source of the Beaver Mill tailings). Tailings have also migrated into Crosswise Lake from the Dominion Reduction Mill via Peterson Creek and from a small creek draining the east end of the Dominion Reduction tailings area. The tailings have filled the northern end of the lake extending from the Silver Cliff Mill north to the Ontario Ministry of Northern Development, Mines, and Forestry (MNDMF) tailings dam at the head of the lake. This area is 25 hectares in size and represents 25% of the lake's original surface area. The tailings extend south of the Silver Cliff Mill underwater however the extent of this is unknown.

Tailings also extend for 1800 metres northeast of the MNDMF dam to the Ministry of the Environment's tailing dam on Far Creek at 2nd Street, North Cobalt. The tailings in this area consist of tailings that have migrated from Crosswise Lake, Mill Creek and Sasaginaga Creek and cover an area of 58 hectares. This area is covered by a wetland that has largely revegetated the site (the above background information is from Anderson, 1993).

Sampling at the Crosswise Lake Tailings was conducted from June 14th to the 16th, 2005. Eighty-nine samples were collected from fifteen sampling locations on the tailings (refer to Maps A24.1 and Figure 4.3.8). No sampling was conducted north of the tailings dam located at the north end of the lake. All samples consisted of a composite of 10 cores taken from 5 x 5 m areas. Cores were taken in 10 cm increments to a depth of 30 or 40 cm. Sampling at the two mine areas along the east side of Crosswise Lake was conducted on June 26, 2006. Eighteen samples were taken from nine locations, three locations at the mine site located on the north end of the lake and six locations at the mine site located near the middle of the lake. All of the mine site samples were a composite of ten trowel samples, 0 to 5 cm deep, taken from areas ranging in size between 1 x 1 m to 5 x 5 m.

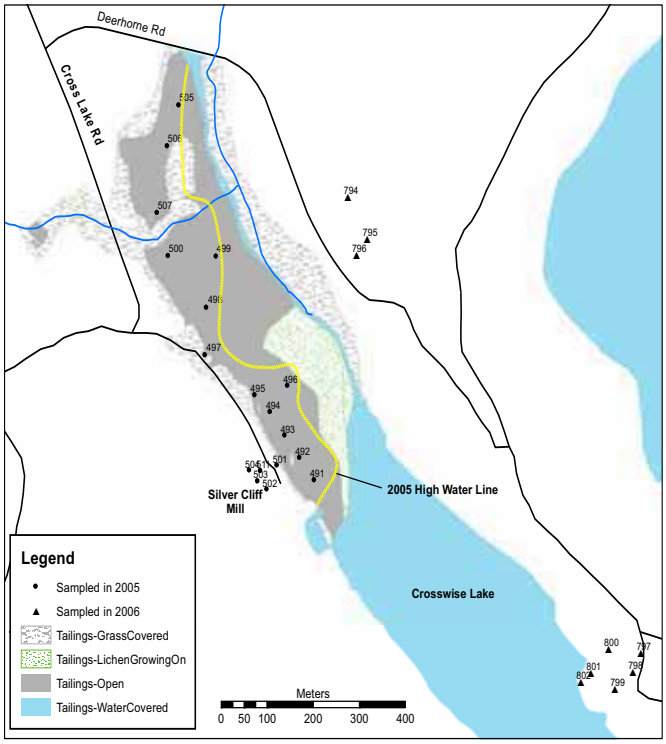


Figure 4.3.8: Crosswise Lake tailings map (Pat Anderson).

The results of the chemical analysis of the samples collected from Crosswise Lake Tailings and Mines are given in Appendix C, Tables C25.a and C25.b. Table C25.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C25.b. Results in Table C25.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Crosswise Lake Tailings and mines on the east side of the lake are given below in Table 4.3.8.1 and Table 4.3.8.2 respectively.

Table 4.3.8.1: Summary of Chemical Analysis of Soil Samples from Crosswise Lake Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	15000	0.2	290	1	0.3	0.2	2100	38	81	66	28000	53	13000	280	0.007	0.4	27	<0.2	5	3	69	60
5th	18000	1.1	600	2	0.4	0.2	2800	55	140	80	31000	69	15000	310	0.18	0.7	62	<0.2	10	3	72	74
25th	20000	3	860	7	0.6	0.5	12000	73	180	130	33000	160	18000	470	0.46	1.2	78	<0.2	21	8	98	150
50th	21000	5	1400	9	0.9	0.9	13000	84	280	160	36000	300	20000	520	0.8	1.7	100	1.0	34	9	110	180
75th	24000	8	3000	11	1.1	1.2	17000	96	870	250	43000	370	21000	640	1.7	3	160	1.0	42	13	130	240
95th	29000	14	5300	18	1.2	3	26000	120	1600	630	51000	820	29000	840	3.1	9	340	1.0	59	18	140	870
Maximum	33000	16	15000	27	1.4	4	34000	580	2600	740	69000	930	38000	890	4.3	13	470	1.8	98	20	160	1300
Stations [1]	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Samples [2]	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
OTR_{98} [3]	15	-	-	-	-	-	0	-	-	-	65	-	79	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	84	89	0	2	34	ns	69	89	83	ns	72	ns	ns	82	27	87	0	89	ns	77	58
Table 2 [5]	ns	6	89	0	2	0	ns	0	89	24	ns	56	ns	ns	0	0	24	0	68	ns	0	8

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of the sampling, significant portions of the tailings visible in air photos taken in 1983 and on the tailings map prepared by Pat Anderson, were under water. All the tailings east of stations 496, 499 and 506 were under water (see dashed yellow line in Figure 4.3.8). There was considerable variation both in the texture of tailings and in the XRF readings taken during sampling activities. In certain cases these differences occurred over very small distances such as where the tailings from the O'Brien Mill enter the lake from Peterson Creek. The tailings at Crosswise Lake ranged in texture from medium grained sand to fine sand or silt. Only sparse Baltic rush was observed growing on the tailings.

There were numerous signs of human activity on the Crosswise Lake tailings. People were observed swimming at the south end of the tailings. There were tire tracks extending from the end of the road to the swimming area. A number of bonfire pits were also located near the swimming area. The tailings had been deeply rutted by large 4 x 4 vehicles between stations 495 and 497 and fresh ATV and snowmobile tracks were observed on the north end of the tailings.

Arsenic and cobalt exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all 89 of the samples collected from the Crosswise Lake tailings. Antimony exceeded the Table 2 standards in 7% of the samples, copper in 27%, lead in 63%, nickel in 27%, and silver in 76%. Arsenic concentrations in the tailings ranged from 290 to 15,000 µg/g with a median concentration of 1,400 µg/g. Of the other metals, cobalt and lead were the most significantly elevated, ranging from 81 to 2,600 µg/g Co and 53 to 930 µg/g Pb.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel and silver at the Crosswise Lake tailings are presented in Appendix A, Maps A24.2 to A24.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There is no clear pattern of spatial distribution for any of the elements in the tailings. Arsenic concentrations in the high use swimming area located at the south end of the tailings were slightly less than the middle portions of the tailings. Arsenic concentrations also dropped slightly at the north end of the tailings. The highest concentrations were found at stations 495 and 496 just north of the swimming area and at station 500 located at the mouth of the Peterson Creek where the O'Brien Mill tailings enter the lake.

The results of the Pearson Correlations analysis on the tailings results showed no significant correlations between arsenic and any other element. The graphs of arsenic with antimony, cobalt, lead, mercury, nickel, and silver show a large degree of scatter in the data. Given that the Crosswise Lake tailings originated from five different mills this lack of correlation is not unexpected.

Table 4.3.8.2: Summary of Chemical Analysis of Soil Samples from the Mines on East Side of Crosswise Lake

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	3700	1.0	150	10	0.1	0.9	130	15	8	80	31000	49	3200	150	0.074	<0.3	6	<0.2	2	4	44	100
5th	4000	1.0	280	11	0.1	1.1	160	16	9	86	31000	50	3500	150	0.12	0.5	7	<0.2	3	4	44	110
25th	14000	1.6	460	12	0.2	3	1100	58	37	240	43000	210	9900	370	0.18	1.4	28	0.3	14	7	52	260
50th	16000	11	2800	19	0.3	4	4600	88	160	860	66000	1000	14000	520	0.54	4	140	1.0	42	10	62	430
75th	28000	20	4800	27	0.6	5	17000	95	420	1400	150000	1900	26000	580	1.2	5	420	1.6	68	24	110	1000
95th	41000	52	7400	150	1.5	7	23000	280	2000	2000	180000	3900	45000	1100	8.4	10	910	6	550	170	130	1800
Maximum	43000	55	8200	370	1.5	7	23000	280	2100	2000	200000	4300	46000	1200	8.8	12	990	7	620	180	130	2000
Stations [1]	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Samples [2]	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
OTR_{98} [3]	5	-	-	-	-	-	0	-	-	-	16	-	7	0	-	-	-	-	-	4	-	-
Table 1 [4]	ns	14	18	1	2	17	ns	12	14	17	ns	16	ns	ns	12	12	10	2	18	ns	6	14
Table 2 [5]	ns	8	18	0	2	0	ns	0	13	14	ns	13	ns	ns	0	0	7	0	10	ns	0	7

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, two mine sites were located on the east side of Crosswise Lake. The mine site at the north end of the lake consisted of large areas of waste rock, old wooden building debris, and recently deposited garbage. The mine site half-way down the eastern shore of the lake consisted of waste rock, two concrete pads, and a small amount of garbage. The waste rock pile at this mine site extended out into the lake. Although both these sites can be accessed by car, the condition of the road was more suitable to 4x4 and ATV vehicles. There were signs of recent human activity at both mine sites.

Arsenic was the only element that exceeded both of the O. Reg. 153-04 Table 1 Background and Table 2 Generic soil standards in all of the eighteen samples collected from the Crosswise Lake mine sites. Antimony exceeded the Table 2 standards in 44% of the samples, cobalt in 72%, copper in 78%, lead in 72%, nickel in 39%, and silver in 6% of the samples. The concentrations of arsenic and other metals were similar between the two mine sites. Arsenic concentrations at the northern mine site ranged from 150 to 8,200 µg/g while at the southern mine site, arsenic ranged from 300 to 6,900 µg/g at the southern mine site. Of the other metals, cobalt, copper, and lead were the most significantly elevated, ranging from 8 to 2,100 µg/g Co, 80 to 2000 µg/g Cu, and 49 to 4,300 µg/g Pb. As was was observed at the Colonial Mine waste rock dump, higher concentrations of lead and arsenic were found in the rust-coloured waste rock while significantly lower concentrations were found in the grey-coloured waste rock.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the two mine sites are presented in Appendix A, Maps A24.2 to A24.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. At the northern mine site, arsenic, cobalt, copper, lead and nickel concentrations at station 794, in amongst the building debris and garbage, were much higher that those found at the other two sites which were waste rock dumps. Arsenic at stations 795 and 796 were typical of grey-coloured waste rock found in the Cobalt-Coleman Mining Camp ranging from 150 to 550 µg/g, while at station 794, arsenic concentrations ranged from 7,300 to 8,200 µg/g. The high concentrations at station 794 were not consistent with the rust-coloured waste rock found elsewhere and may have originated from ore-bearing material or a processing activity.

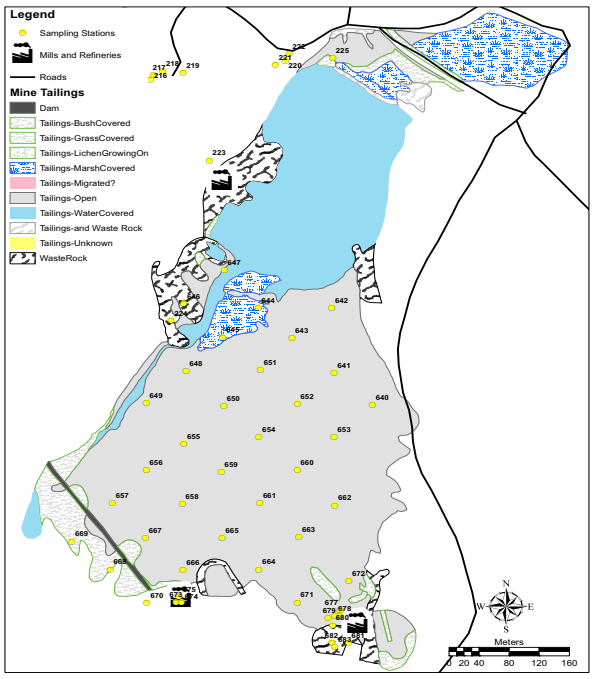
At the southern mine location, stations 797 and 798, consisting of rust-coloured waste rock, had low concentrations of arsenic, cobalt, copper, lead, and nickel that were more typical of the low concentrations normally found in grey-coloured waste rock. At stations 799 and 800, along the top edge of the waste rock dump, the waste rock was light grey in colour but had high concentrations of arsenic, cobalt, copper, lead, and nickel. Stations 801 and 802, along the lake

edge, consisted of rust-coloured waste rock and had high concentrations of arsenic, cobalt, copper, lead, and nickel. Although in general, high concentrations of arsenic, lead and other metals were typically associated with rust-stained waste rock in the Cobalt-Coleman Mining Camp, this site shows that this was not always the case.

The results of the Pearson Correlations analysis of the data from the two mine sites were mixed. Arsenic was shown to be significantly correlated with antimony, cobalt, copper, and molybdenum however there was a lot of scatter in the data and a small number of high values helped to drive the correlations.

4.3.9 Cart Lake Tailings

Five mills deposited tailings into Cart Lake from 1910 to 1983. The Seneca-Superior Mill on the west side of the lake operated from 1913 to 1919. The Cobalt Provincial Mill, located on at the south end of the lake, operated from 1911 to 1920, and in 1938. The Savage Mill, located on the southeast corner of the lake, operated from 1910 to 1912. The Helen's Mill located on Cobalt Lake pumped tailings to the north end of Cart Lake in the 1950's. The Silver Summit Mill, established on the Savage Mill site, operated from 1963 to 1983 and was the largest source of tailings to the lake. Tailings almost completely fill the lake. Only 6 hectares, or 24% of the 25 hectare lake, still exist as a shallow water body. It is estimated that there are 1.2 million tons of tailings in the lake. A small tailings reclamation project was conducted on the tailings in 1979 and vegetation is still growing in this area (the above background information is from Anderson, 1993).



Preliminary sampling of the Cart Lake tailings was conducted on August 16, 2004 when sixteen samples were collected at two locations. One location (station 225) was established at the north end of the lake in an area where Baltic rush was growing. The second location (station 224) was established at the end of the road leading south from HST Site 5. The main sampling of the Cart Lake tailings was conducted from September 26 to 27, 2005. One hundred and twenty-five samples were collected from thirty-two sampling locations (refer to Map A23.1 and Figure 4.3.9). All samples consisted of a composite of 10 cores taken from 5 x 5 m areas. Cores were taken at 10 cm increments to a depth of 30 or 40 cm.

Figure 4.3.9: Cart Lake tailings (Pat Anderson, 1996)

At the time of sampling, the northern third of the Cart Lake tailings were largely under water. The tailings above the water line sloped upward in a southeast direction towards the Silver Summit Mill. There was dense growth of Baltic rush along the north end of the lake in the shallows by the road. In the southern two thirds of the lake, above the water line, there was a gradient of vegetation ranging from large open areas with sparse outcrops of Baltic rush growing at lower elevations near the waterline to more dense cover of arsenic-tolerant moss,

rough bentgrass (*Agrostis scabra* Willd.), Baltic rush (*Juncus balticus*) and horsetails (*Equisetum sp.*). An exception to this was in the vicinity of station 659 which had been re-vegetated in the past. In this area there was a thick cover of grass and herbaceous species. Human activity observed at the Cart Lake tailings included tourists walking on the tailings and a local resident training his dogs to retrieve items from the lake. A number of ATV tire tracks were also observed on the tailings.

The results of the chemical analysis of the samples collected from Cart Lake tailings are given in Appendix C, Tables C26.a and C26.b. Table C26.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C26.b. Results in Table C26.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.9.1 below.

Table 4.3.9.1: Summary of Chemical Analysis of Soil Samples from the Cart Lake Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	18000	0.9	200	5	0.6	0.5	7000	60	65	35	32000	96	15000	400	0.063	0.3	49	0.2	6	5	85	98
5th	19000	1.0	280	6	0.7	0.6	7600	79	97	47	33000	120	16000	450	0.3	0.34	60	0.2	9	5	90	110
25th	20000	2.2	520	8	0.7	0.77	9400	87	140	64	35000	130	17000	480	0.44	0.6	75	0.2	13	6	99	130
50th	21000	3.6	780	9	0.7	1.0	11000	94	170	78	37000	140	18000	530	0.54	0.8	86	1.0	15	7	110	150
75th	22000	5.2	1200	10	0.8	1.2	12000	100	210	95	40000	180	18000	580	0.69	1.0	110	1.0	19	9	120	190
95th	25000	8.6	1800	14	1.0	1.5	16000	120	330	250	45000	220	20000	640	2.4	1.6	140	1.0	37	12	130	260
Maximum	32000	12	2200	21	1.2	11	18000	140	570	360	53000	310	26000	750	6.7	2.1	210	1.0	60	21	150	380
Stations [1]	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
Samples [2]	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141	141
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	133	-	112	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	130	141	0	0	54	ns	140	141	55	ns	116	ns	ns	138	0	141	0	141	ns	129	56
Table 2 [5]	ns	0	141	0	0	0	ns	0	141	8	ns	17	ns	ns	0	0	6	0	26	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic and cobalt were the only elements that exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all 141 of the samples collected from the Cart Lake tailings. Concentrations of copper, lead, mercury, nickel, and silver were low with only 6%, 12%, 0%, 4%, and 18% of the samples respectively exceeding the *Table 2 Generic Standards*. Concentrations of arsenic ranged from 200 to 2,220 µg/g with a median concentration of 780 µg/g. The range of arsenic concentrations was larger than what was found at other tailings in the Cobalt-Coleman Mining Camp. Although the range in concentrations observed may be attributed to the number of mills that have deposited tailings into the lake, the majority of the surface tailings found at the southern end of the lake originated from the Silver Summit Mill.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Cart Lake tailings are presented in Appendix A, Maps A23.2 to A23.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There was no pattern to the distribution of arsenic over the Cart Lake tailings. The range of concentrations of the other metals was too small to discern any spatial pattern. There was also no consistent pattern of decreasing or increasing concentrations of arsenic or metals with depth. There was a small increase in the median arsenic

concentration at the 30 to 40 cm depth in comparison to the 0 to 10, 10 to 20 and 20 to 30 cm depths.

The results of the Pearson Correlation analysis show arsenic is only significantly correlated with cobalt. The graphing of arsenic versus antimony, cobalt, lead, mercury, nickel, and silver show a general trend of increasing concentrations of these metals with increasing arsenic concentration however there is a lot of scatter in the data. The degree of correlation between aluminum, chromium, iron, magnesium, manganese, and vanadium indicate that the tailings came largely from the same ore body.

4.3.10 Cobalt Provincial Mill

The Cobalt Provincial Mill is located at the north end of Gillies Limit Township on the south shore of Cart Lake. The original mill was built in 1911, consisting of a small plant for coarse concentration. The mill was enlarged in 1918 into a full gravity concentrator and operated until 1920. It was reopened briefly in 1938. The tailings were deposited directly into the south end of Cart Lake. Only a small portion of the mill's foundations currently remain (the above background information is from Anderson, 1993).

Sampling at the Cobalt Provincial Mill was conducted on September 28, 2005. Eight samples were collected from three sampling locations at the mill site (refer to Maps A23.1). Because of the varied nature of the site, samples w ere either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples. There was only a small concrete foundation left at this site at the time of sampling. It appeared that most of the mill's foundations had been buried under tailings from the Silver Summit Mill. The material at sampling stations 673 and 675 appeared to be tailings that had migrated into the foundations. Station 674 was established in a pile of waste rock and mill waste at the rear of the foundations.

The results of the chemical analysis of the samples collected from Cobalt Provincial Mill are given in Appendix C, Tables C27.a and C27.b. Table C27.a includes those elements for which there are *Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C27.b. Results in Table C27.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.10.1 below.

Table 4.3.10.1: Summary of Chemical Analysis of Soil Samples from the Cobalt Provincial Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	21000	1.0	170	13	0.7	0.6	2800	81	110	41	38000	38	15000	320	0.15	<0.3	60	<0.2	5	5	83	64
25th	22000	1.3	190	15	0.9	1.0	5600	88	110	46	39000	59	16000	340	0.25	0.5	71	<0.2	8	5	86	82
50th	22000	1.7	340	16	1.0	1.2	6700	93	120	62	40000	140	18000	460	0.38	0.7	79	<0.2	9	6	98	160
75th	23000	7	3100	21	1.2	1.5	9300	100	1200	260	43000	240	19000	590	2.3	2.0	280	0.4	82	8	100	220
Maximum	24000	20	11000	23	1.6	2	18000	100	4500	910	45000	580	22000	980	9.2	6	1000	1.0	330	12	110	440
Stations [1]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	8	-	5	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	7	8	0	2	6	ns	8	8	2	ns	5	ns	ns	7	2	8	0	8	ns	5	2
Table 2 [5]	ns	2	8	0	2	0	ns	0	8	2	ns	2	ns	ns	0	0	2	0	2	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic and cobalt were the only elements that exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all eight of the samples collected from the Cobalt Provincial Mill. Exceedances of the *Table 2 Generic Standard* for antimony, copper, lead, nickel, and silver were found only in the samples collected from station 674. Arsenic concentrations of the tailings-like material ranged from 190 to 410 µg/g while the arsenic concentration of the waste rock / mill waste material was 11,000 µg/g.

The results of the Pearson Correlations analysis show a high correlation between the majority of elements. The graphs of these relationships however indicate that the correlations are the result of the large difference in concentrations between the tailings and mill waste material.

4.3.11 Silver Summit Mill

The Savage Mill was built at the south end of Cart Lake, just east of the Cobalt Provincial Mill, in 1910. It was located in the S½, N½ of Lot 6, Concession V, Coleman Township. The mill only operated for three years and was closed when an aerial tramway was built to ship the ore to the McKinley-Darragh Mill. In 1963, the 200 ton per day Silver Summit Mill was built on the same site as the original Savage Mill. The mill ceased operation in 1964 due to lack of ore. It was purchased and reopened in 1965 by Silverfields Mining Corporation and operated until 1983. Processing at the Silver Summit Mill included grinding the ore to No. 200 Mesh (0.075mm) size and separating the silver by both gravity and flotation. This fine grinding resulted in tailing slimes consisting of very fine sand and silt. Tailings from the mill were deposited into the south end of Cart Lake (the above background information is from Anderson, 1993).

Sampling at the Silver Summit Mill was conducted on September 28, 2005. Sixteen samples were collected from eight sampling locations at the mill site (refer to Maps A23.1). Because of the varied nature of the site and the nature of the material being sampled, samples were 0 to 5 cm trowel samples taken from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 trowel samples. At the time of sampling the only buildings still standing at the site were the headframe and a storage building. Only the concrete floor and foundation of the main mill building remained. The headframe and part of the mill's foundations had been fenced off as mine hazards. Several piles of soil covered with plastic were located on the floor of the lower portion of the mill (refer to Figure D490). These piles appeared to be contaminated with diesel fuel and were not sampled. Sampling was limited to the waste material located along the northwest and southwest sides of the mill's foundations. The material sampled had substantial amounts of small to medium size waste rock in it.

The results of the chemical analysis of the samples collected from Silver Summit Mill are given in Appendix C, Tables C28.a and C28.b. Table C28.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C28.b. Results in Table C28.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.11.1 below.

Table 4.3.11.1: Summary of Chemical Analysis of Soil Samples from the Silver Summit Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	10000	5	810	11	0.4	1.1	1600	50	250	290	25000	190	7900	340	2.0	0.7	120	<0.2	51	6	52	300
5th	11000	7	870	12	0.4	1.3	1700	51	260	330	25000	210	8600	340	2.1	0.8	130	<0.2	56	6	52	300
25th	12000	46	3800	17	0.5	3	4900	64	420	1600	34000	1100	11000	450	17	2.0	270	1.0	610	7	74	740
50th	14000	160	7000	24	0.6	4	6900	72	1100	2000	38000	1800	12000	490	30	5	400	1.0	1600	10	83	1000
75th	15000	340	16000	43	0.7	7	8300	83	2300	4100	45000	5400	13000	520	68	12	830	1.1	2800	17	90	2000
95th	18000	2000	31000	99	0.7	10	37000	140	5000	9600	110000	10000	16000	590	640	32	1500	1.6	17000	73	120	2700
Maximum	19000	2800	31000	100	0.8	12	38000	150	5600	9900	120000	11000	16000	650	770	32	1700	1.8	24000	76	120	3000
Stations [1]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Samples [2]	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	12	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	16	16	0	0	16	ns	8	16	16	ns	16	ns	ns	16	11	16	0	16	ns	4	16
Table 2 [5]	ns	14	16	0	0	0	ns	0	16	16	ns	15	ns	ns	12	0	14	0	16	ns	0	12

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic, cobalt, copper, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all sixteen of the samples collected from the Silver Summit Mill. Antimony exceeded the *Table 2 Generic Standard* in 88% of the samples, lead in 94%, mercury in 75%, nickel in 88%, and zinc in 75% of the samples. Arsenic concentrations ranged from 810 to 31,000 µg/g with a median concentration of 7,000 µg/g. Concentrations of antimony, cobalt, copper, lead, mercury, nickel, silver, and zinc were very high at this site.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Silver Summit Mill are presented in Appendix A, Maps A23.2 to A23.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentrations of arsenic and metals was found in rust-stained waste rock material at stations 682 and 683 located 20 m to the south west of the mill's main foundations and at station 679 located at the northwest corner of the foundations.

The results of the Pearson Correlations analysis show a large number of significant correlations between various metals. Arsenic was significantly correlated with antimony, cobalt, cadmium, lead, mercury, molybdenum, nickel, silver, and zinc. Although these correlations were influenced somewhat by the high values found at station 682, the trends still hold if this data is removed. The high degree of correlations between the different heavy metals suggests that this material is waste from the milling process.

4.3.12 Mensilvo (Silver Arrow) Mill and Tailings

The Mensilvo Mill located in the SW ¼ of the N ½ of Lot 5, Concession IV, Coleman Township was built in 1947. The mill operated intermittently between 1947 and 1957 with additions made to the mill in 1953 and 1955. The mill was relatively small, initially operating at 25 tons per day. The property was purchased by Silver Summit Mines Limited in 1963 but the mill was not re-opened.

It is estimated that 30,000 tons of milling was performed at the site. The tailings were deposited into a small valley to the southeast of the mill. There appears to have been no tailings dam at this site and the tailings have migrated across the road and down a creek bed into Contact Bay of Giroux Lake. The tailings cover an area of approximately 3.4 hectares in size (the above background information is from Anderson, 1993).

Sampling at the Mensilvo Mill and Tailings was conducted from June 27th to 29th, 2005. Twenty-four samples were collected from eleven sampling locations at the mill site (refer to Map A25.1 and Figure 4.3.12). Because of the varied nature of the mill site and the nature of the material being sampled, samples were either 0 to 5 cm trowel samples or core samples taken at multiple depths from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores or trowel samples. Seventy-two samples were collected from twelve sampling locations on the tailings. Tailings samples were collected with a corer at 10 cm increments to a depth of 30 cm from 5 x 5 m areas. All tailing samples were composites of a minimum of 10 cores.

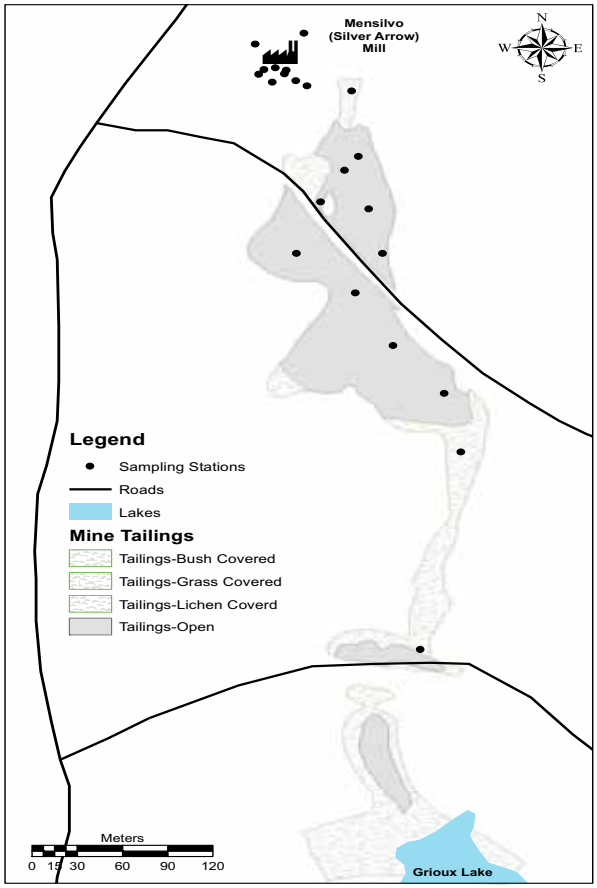


Figure 4.3.12: Mensilvo Tailings Map

The results of the chemical analysis of the samples collected from Mensilvo Mill and Tailings are given in Appendix C, Tables C29.a and C29.b. Table C29.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards* Table 2 *Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C29.b. Results in Table C29.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Mensilvo Mill and Mensilvo Tailings are given below in Table 4.3.12.1 and Table 4.3.12.2 respectively.

Table 4.3.12.1: Summary of Chemical Analysis of Soil Samples from Mensilvo Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5400	15	6800	12	0.4	2	930	30	62	2200	50000	2000	4100	120	1.1	5	23	1.0	95	3	59	490
5th	5900	21	8100	13	0.4	3	940	34	73	2500	50000	2500	4600	140	1.6	6	26	1.0	100	4	61	490
25th	14000	68	21000	16	0.6	5	1600	70	200	3900	53000	4700	9400	400	2.3	14	200	1.0	140	4	89	650
50th	16000	120	26000	20	0.9	6	2800	84	960	4800	58000	10000	14000	620	3.6	34	340	1.0	220	6	100	1200
75th	18000	200	35000	24	1.0	8	8800	96	1600	5600	63000	23000	16000	860	4.7	76	450	1.5	350	8	120	1800
95th	25000	730	48000	61	1.1	9	29000	100	5700	6600	110000	61000	20000	1400	6	170	1500	5	590	24	140	2400
Maximum	27000	800	53000	70	1.2	12	35000	110	6000	6700	120000	65000	20000	1600	11	190	1600	5	640	25	150	2900
Stations [1]	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Samples [2]	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	24	-	3	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	24	24	0	0	24	ns	15	24	24	ns	24	ns	ns	24	24	20	5	24	ns	17	24
Table 2 [5]	ns	24	24	0	0	0	ns	0	24	24	ns	24	ns	ns	1	11	18	0	24	ns	0	21

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.3.12.2: Summary of Chemical Analysis of Soil Samples from the Mensilvo Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	20000	3	890	5	0.7	0.6	13000	72	300	410	37000	300	15000	770	0.096	1.4	110	1.0	6	7	110	360
5th	21000	4	1200	7	0.7	0.9	16000	82	340	560	40000	360	17000	810	0.15	1.5	120	1.0	7	9	110	420
25th	22000	7	2300	9	0.8	1.1	18000	87	660	770	42000	430	18000	870	0.24	2.0	160	1.0	14	10	120	480
50th	22000	11	3300	10	0.9	1.7	20000	92	1000	1000	44000	500	18000	890	0.40	2.4	220	1.0	21	10	130	560
75th	23000	21	6400	13	1.0	2.2	21000	98	1700	2000	47000	650	19000	970	0.52	3	400	1.0	30	11	140	800
95th	24000	31	13000	16	1.3	3	24000	100	4200	3200	53000	880	20000	1000	0.74	5	690	1.2	43	12	150	1300
Maximum	26000	47	21000	17	1.4	5	28000	120	6200	3900	53000	1300	22000	1100	0.96	7	880	2	52	15	160	1500
Stations [1]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Samples [2]	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	72	-	70	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	72	72	0	5	63	ns	72	72	72	ns	72	ns	ns	54	33	72	1	72	ns	72	72
Table 2 [5]	ns	29	72	0	5	0	ns	0	72	72	ns	72	ns	ns	0	0	56	0	37	ns	0	29

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, the Mensilvo Mill had been totally demolished and only a small part of the concrete foundations in the southwest corner of the mill site were still visible. The rest of the mill's foundations had been covered over with waste rock. Mill waste was visible only to the south and west of the concrete foundations. The mill waste to the south of the foundations was reddish-brown in colour while the mill waste to the west of the concrete foundations was dark grey and had a large amount of drill core segments mixed in with the waste. Some of the mill waste had migrated down a drainage channel to the southwest of the foundations towards the tailings area (stations 517, 525, 526, and 527). There was no vegetation growing on the mill waste around the mill. The tailings area was sparsely vegetated with arsenic tolerant Baltic rush and rough bentgrass. There were recent signs of human activity at the mill site including ATV tracks, recent garbage, and a small child's bootprint. ATV tracks were also observed on the tailings.

Antimony, arsenic, cobalt, copper, lead, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty-four of the samples collected from the Mensilvo Mill. Nickel exceeded the Table 2 Generic standard in 75% of the samples, zinc in 88%, and mercury in only 4% of the samples. Arsenic concentrations were very high ranging from 6,800 to 53,000 µg/g with a median concentration of 26,000 µg/g. Concentrations of antimony, cobalt, copper, lead, nickel, silver, and zinc were also very high around the mill site. The concentrations of lead were some of the highest found in the Cobalt-Coleman Mining Camp ranging from 2,000 to 65,000 µg/g with a median concentration of 10,000 µg/g.

As would be expected, concentrations of arsenic and metals in the tailings were lower than those found in the mill waste. Only arsenic, cobalt and lead exceeded both of the *O. Reg. 153-04 Table*

1 Background and *Table 2 Generic* soil standards in all seventy-two of the samples collected from the Mensilvo tailings. Antimony exceeded the *Table 2 Generic* standard in 40% of the samples, nickel in 78%, silver in 51%, and zinc in only 40%. Arsenic concentrations ranged from 890 to 21,000 µg/g with a median concentration of 3,300 µg/g. The arsenic concentrations in the tailings were higher than typically found in medium to coarse grained tailings and were more typical of fine grained tailings. The concentrations of lead in the tailings were also high for tailings ranging from 300 to 1,300 µg/g with a median concentration of 500 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Mensilvo Mill and tailings are presented in Appendix A, Maps A25.2 to A25.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentrations of arsenic, lead and other metals were found in the mill wastes to the south and east of the mill's foundations. Concentrations in the waste rock fine m aterial covering the mill were much lower. There appears to be a minor gradient in the concentrations of arsenic and other metals in the tailings with the highest concentrations found at the north end of the tailings closer to the mill and decreasing to the south.

The results of the Pearson Correlations analysis for the mill site show little correlation between arsenic and any of the heavy metals (refer to Table B28.a). The plots of arsenic with antimony, cobalt, lead, mercury, nickel, and silver show a general trend of increasing metals concentrations with increasing arsenic concentration however there was a lot of scatter in the data (refer to Figures B28.a.1 to B29.a.6). There were significant correlations with aluminum, chromium, magnesium, manganese, and vanadium indicating that the material was from a common source. The correlation analysis of the tailings showed a strong correlation between arsenic, cobalt, copper, molybdenum, and nickel and a moderate correlation with antimony and molybdenum (refer to Table B26.b). The correlations of aluminum, chromium, magnesium, manganese, and vanadium observed in the mill waste were not present in the tailings.

4.3.13 Silver Miller Mill and Tailings

The Silver Miller Mill was built by Silver-Miller Mines in 1949 on the foundation of the former Northern Ontario Power Company sub-station. The mill was originally a 50 ton per day operation which was increased to 100 tons per day in 1952. The mill closed in 1957 and was demolished in the late 1980's. Ore was processed using a combination of wet gravity and flotation processes.

The majority of the tailings were sluiced to the Temiskaming tailings area. A small amount of tailings held back by a tailings dam are located just northwest of the mill site. Some of these tailings have migrated past the dam towards Bradey Lake (the above background information is from Anderson, 1993).

Sampling at the Silver Miller Mill and Tailings was conducted on August 30, 2005. Ten samples were collected from five sampling locations at the mill site (refer to Maps A26.1). Because of the varied nature of the mill site and the nature of the material being sampled, samples were 0 to 5 cm trowel samples taken from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 trowel samples. Six samples were collected from one sampling location established on the tailings. Tailings samples were collected with a corer at 10 cm increments to a depth of 30 cm from 5 x 5 m areas. All tailing samples were composites of a minimum of 10 cores.

The results of the chemical analysis of the samples collected from Silver Miller Mill and

Tailings are given in Appendix C, Tables C30.a and C30.b. Table C30.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C30.a. Results in Table C30.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Silver Miller Mill and Silver Miller Tailings are given below in Table 4.3.13.1 and Table 4.3.13.2 respectively.

Table 4.3.13.1: Summary of Chemical Analysis of Soil Samples from the Silver Miller Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	14000	6	2100	5	1.1	1.0	9800	33	460	530	29000	620	8000	340	0.34	2.1	130	1.0	43	9	67	310
25th	17000	13	3200	14	1.3	2.6	10000	48	540	1900	40000	1600	8700	420	0.44	3.6	190	1.7	49	15	71	820
50th	18000	19	3900	60	2.1	6.4	14000	70	760	2600	49000	3800	9900	480	3.4	4	220	2.4	390	140	77	1600
75th	27000	150	16000	140	3.7	22	27000	120	2800	3200	59000	5600	23000	840	24.0	5	480	3	2100	200	96	8300
Maximum	29000	190	16000	350	6	26	48000	140	3200	3300	67000	7000	24000	910	50	6	620	5	3600	420	100	10000
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	9	-	4	0	-	-	-	-	-	6	-	-
Table 1 [4]	ns	10	10	1	9	9	ns	5	10	10	ns	10	ns	ns	10	9	10	7	10	ns	4	10
Table 2 [5]	ns	7	10	0	9	4	ns	0	10	10	ns	10	ns	ns	4	0	9	0	10	ns	0	9

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.3.13.2: Summary of Chemical Analysis of Soil Samples from the Silver Miller Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	21000	7	640	15	0.3	0.7	23000	46	140	120	29000	75	13000	520	0.38	0.3	53	1.0	25	18	100	81
25th	22000	7	770	15	0.3	0.8	24000	48	140	130	29000	78	13000	520	0.44	0.3	53	1.0	42	19	100	82
50th	22000	8.2	800	16	0.32	0.8	24000	50	150	130	29000	84	14000	540	0.57	0	54	1	44	20	100	90
75th	22000	9.7	1000	16	0.3	1	25000	52	170	140	29000	89	14000	560	0.7	0	62	1	70	20	100	110
Maximum	23000	11	1200	17	0	0.94	25000	53	200	150	30000	92	14000	590	0.87	1	76	1	87	20	100	110
Stations [1]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Samples [2]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	6	6	0	0	0	ns	0	6	6	ns	0	ns	ns	6	0	6	0	6	ns	6	0
Table 2 [5]	ns	0	6	0	0	0	ns	0	6	0	ns	0	ns	ns	0	0	0	0	6	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, the mill had been demolished and the majority of the foundations had been covered over with waste rock. Mill waste material was observed only along the northwest and northeast edges of the mill site. The area covered with tailings was largely unvegetated interspersed with a few birch and aspen seedlings. The areas of mill waste were sparsely vegetated with arsenic tolerant rough bentgrass. The tailings to the north of the mill were vegetated with Baltic rush, rough bentgrass, and horsetails.

Arsenic, cobalt, copper, lead and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all ten of the samples collected from the Silver Miller Mill. Antimony exceeded the *Table 2 Generic* standard in 70% of the samples, nickel and zinc in 90% of the samples, and mercury in 40% of the samples. Arsenic concentrations ranged from 2,100 to 16,000 µg/g with a median concentration of 3,900 µg/g. Concentrations of lead were also high, particularly in the waste rock cover, with concentrations ranging from 620 to 7000 µg/g. The concentrations of arsenic and metals in the tailing were lower than the mill waste with only

arsenic, cobalt, and silver exceeding both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all six of the samples collected from the tailings area. None of the other elements exceeded the Table 2 standards.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Silver Miller Mill and Tailings are presented in Appendix A, Maps A26.2 to A26.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentrations of arsenic, antimony, nickel, and silver were found at stations 614 and 618 in the mill waste located along the northwest edge of the mill. The pattern for lead was totally different with the highest concentrations being found at stations 616 and 617 in the rust-coloured waste rock covering the mill's foundations.

The results of the Pearson Correlations analysis of the mill site samples show a high degree of correlation between arsenic, cobalt, mercury, cobalt, and silver (refer to Table B27 and Figures B27.1 to B27.6). There were also a large number of significant correlations between other elements. As with other sites, this high number of correlations is driven by the difference in concentrations between the waste rock cover material and the mill waste resulting in two groups of data forming a line between two points (as seen in the graphs of arsenic with antimony, cobalt, lead, mercury, nickel, and silver). The six samples from the tailings area were not sufficient to perform a correlation analysis.

4.3.14 Bradey Lake Mines

There were two mine sites located on the shores of Bradey Lake. One site was located at the northeast end of the lake 250 metres north-northeast of the Silver Miller Mill. The second was located at the south end of the lake. There were no head frames or other buildings left at either site. Concrete foundations were observed at the northern site. Both sites had large waste rock dumps. A significant amount of the waste rock at the northern site had been removed. There was only sparse vegetation growing on the waste rock at either of these sites at the time of sampling.

Sampling at the Bradey Lake Mine sites was conducted on August 31, 2005. Twelve samples were collected from six sampling locations, four locations at the northern mine site and two locations at the southern mine site (refer to Maps A26.1). Because of the varied nature of the mine sites and the nature of the material being sampled, samples consisted of 0 to 5 cm trowel samples taken from 1 x 1 m to 5 x 5 m areas. All samples were composites of a minimum of 10 trowel samples. The majority of the samples were collected from areas of rust coloured waste rock where th e portable XRF had indicated high concentrations of arsenic and lead.

The results of the chemical analysis of the samples collected from Bradey Lake Mine sites are given in Appendix C, Tables C31.a and C31.b. Table C31.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C31.a. Results in Table C31.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Bradey Lake Mine sites are given in Table

4.3.14.1 below.

Table 4.3.14.1: Summary of Chemical Analysis of Soil Samples from the Bradey Lake Mines

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	13000	0.2	120	5	0.2	0.8	500	16	10	290	31000	100	7200	120	0.019	0.6	16	0.3	5	2	63	100
5th	13000	0.2	150	6	0.2	0.9	540	17	11	380	31000	110	7300	120	0.027	0.6	18	0.3	8	3	63	110
25th	16000	4	720	9	0.3	1.4	2000	26	110	500	39000	820	12000	170	0.20	1.5	55	1.0	14	6	74	210
50th	20000	12	2100	10	0.4	2.1	21000	42	160	560	51000	2800	18000	440	0.36	4	66	1.1	29	20	94	440
75th	23000	18	3500	18	0.6	3	46000	45	220	860	110000	4500	22000	700	0.68	9	81	2	150	26	100	700
95th	26000	49	7200	34	0.8	4	68000	170	980	1500	130000	6600	26000	930	12	31	93	6	270	28	120	1000
Maximum	27000	67	8300	35	0.8	5	71000	200	1000	1700	130000	7800	27000	1000	13	40	100	6	350	29	120	1100
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
OTR_{98} [3]	0	-	-	-	-	-	2	-	-	-	10	-	7	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	10	12	0	0	10	ns	2	10	12	ns	10	ns	ns	8	6	9	3	12	ns	7	10
Table 2 [5]	ns	5	12	0	0	0	ns	0	10	12	ns	10	ns	ns	2	0	0	0	7	ns	0	4

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic and copper were the only two elements to exceed both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twelve of the samples collected from the Bradey Lake Mine sites. Antimony exceeded the Table 2 Generic standard in 50% of the samples, copper and lead in 90%, and mercury in 17% of the samples. Arsenic concentrations ranged from 120 to 8,300 µg/g, with a median concentration of 2,100 µg/g. Concentrations of lead were also high, particularly in the waste rock cover with lead ranging from 100 to 7800 µg/g with a median concentration of 2,800 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Bradey Lake mines are presented in Appendix A, Maps A26.2 to A26.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There was no spatial trend to the data.

The results of the Pearson Correlations analysis of the samples for the Bradey Lake mine sites indicated significant correlations between arsenic, barium, chromium, copper, and molybdenum with a weaker correlation to lead (refer to Table B28 and Figures B28.1 to B28.6). Although there was a general trend of increasing arsenic concentrations with increasing concentrations of these elements, there was a lot of scatter in the data.

4.3.15 Cobalt Load Mine

At the time of sampling, the Cobalt Load Mine had been closed, the headframe and buildings demolished, and the mine shaft covered over with waste rock. Immediately north of the mine shaft was an area of barren ground where cobalt ore had been stockpiled. This ore had been relocated to the Canadaska Mill building. Small amounts of the ore was still scattered throughout this area. At the north end of the barren area there was a small area of tailings that had migrated along a creek bed from the Temiskaming tailings area.

Sampling at the Cobalt Load Mine site was conducted on August 31, 2005. Thirty-two samples were collected from fifteen sampling locations (refer to Maps A27.1). Because of the varied nature of the mine site and the nature of the material being sampled, samples were 0 to 5 cm trowel samples taken from 1 x 1 m to 5 x 5 m areas. All samples were composites of a minimum of 10 trowel samples. The majority of the sampling was conducted in the area where the cobalt ore had been stored.

The results of the chemical analysis of the samples collected from Bradey Lake Mine sites are given in Appendix C, Tables C32.a and C32.b. Table C32.a includes those elements for which

there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C32.a. Results in Table C32.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Cobalt Load Mine site are given in Table 4.3.15.1 below.

Table 4.3.15.1: Summary of Chemical Analysis of Soil Samples from the Cobalt Load Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	7600	11.0	790	12	0.2	1.0	1100	35	180	500	23000	250	1700	91	1.6	0.3	95	1	72	6	38	190
5th	8000	12.0	1200	15	0.2	1.2	1400	46	240	770	26000	370	2000	110	2.1	0.6	120	1	81	7	44	260
25th	11000	28	11000	22	0.4	2.3	2100	56	1200	990	41000	800	4300	230	14	2.1	450	1	180	8	56	730
50th	14000	360	36000	28	0.6	6.4	10000	80	2600	3100	48000	3000	11000	430	52.0	10	960	1	240	9	86	1400
75th	23000	820	64000	32	0.8	12	17000	95	4400	4300	65000	6800	18000	760	79.0	15	1500	1.0	500	14	110	2800
95th	25000	1400	85000	39	1.2	19	33000	130	10000	7100	82000	13000	20000	1300	120	23	3400	1.5	880	26	120	4000
Maximum	26000	1900	99000	42	1.5	25	47000	140	12000	8800	100000	16000	26000	1700	160	30	3500	2.5	1100	33	130	6300
Stations [1]	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Samples [2]	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	28	-	10	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	32	32	0	2	31	ns	19	32	32	ns	32	ns	ns	32	23	32	1	32	ns	14	32
Table 2 [5]	ns	29	32	0	2	7	ns	0	32	32	ns	32	ns	ns	24	0	28	0	32	ns	0	24

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic, cobalt, copper, lead and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty-four of the samples collected from the Cobalt Load Mine. Antimony exceeded the *Table 2 Generic Standard* in 91% of the samples, mercury in 75%, nickel in 88%, and zinc in 75% of the samples. Arsenic concentrations were very high, ranging from 790 µg/g in the waste rock around the mine to 99,000 µg/g in the area where the ore was stored, with a median concentration of 36,000 µg/g. Concentrations of antimony, cobalt, copper, lead, nickel, silver, and zinc were also very high around the mine site.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Cobalt Load Mine are presented in Appendix A, Maps A27.2 to A27.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentration of arsenic and metals was found in the ore storage area. The area around the mine shaft, stations 632 and 633, had the lowest concentrations, followed by the tailings area located at the north end of the site (stn. 637).

The results of the Pearson Correlations analysis show that arsenic was significantly correlated with antimony, copper, mercury, and molybdenum and to a lesser extent with lead (refer to Table B29 and Figures B29.1 to B29.6). There was a general trend of high arsenic concentrations with high concentrations of other elements such as cobalt, nickel and silver however there was a high degree of scatter in the data.

4.3.16 Temiskaming Mill & Tailings

The Temiskaming Mill was located in the S½ of the NW¼ of Lot 1, Concession IV, Coleman Township, 230 metres south west of the Beaver Mill and 330 metres north northeast of the Bradey Lake Mill (refer to Figure 4.3.10). The mill was constructed in 1910 and operated until 1921. This was a 100 ton per day mill that crushed the ore to 20 Mesh (0.85 mm) and concentrated the material using a wet gravity process resulting in coarse sand tailings. A flotation unit was added in 1920 but the mill closed shortly afterwards.

Fifty-nine tons of the tailings were removed and reprocessed in 1928 at another mill. In 1951 the remaining tailings were largely removed. From 1948 to 1956, tailings from the Brady Lake Mill were deposited in the original Temiskaming tailings area (the above background information is from Anderson, 1993).

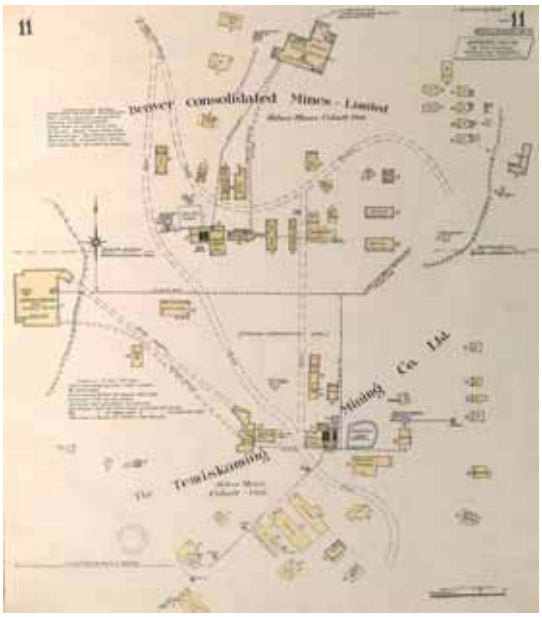


Figure 4.3.10: Beaver & Temiskaming Mines

Sampling at the Temiskaming Mill and Tailings was conducted from August 2nd to the 4th, 2005. Eighteen samples were collected from seven sampling locations at the mill site (refer to Maps A28.1, stations 573 to 577 and 591). Because of the varied nature of the mill site and the nature of the material being sampled, samples consisted of 0 to 10 cm core sam ples taken from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores. Seventy-two samples were collected from twelve sampling locations within the tailings (stations 578 to 589). Tailings samples were collected using a corer from 5 x 5 m areas at 10 cm increments to a depth of 30 cm. All tailing samples were composites of a minimum of 10 cores. All samples were collected in duplicate.

The results of the chemical analysis of the samples collected from Temiskaming Mill and Tailings are given in Appendix C, Tables C33.a and C33.b. Table C33.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C33.b. Results in Table C33.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Temiskaming Mill and Temiskaming Tailings are given below in Table 4.3.16.1 and Table 4.3.16.1 respectively.

Table 4.3.16.1: Summary of Chemical Analysis of Soil Samples from Temiskaming Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	12000	1.0	400	20	0.5	0.5	2400	53	120	220	32000	150	6400	250	0.68	0.6	86	0.2	36	9	77	150
5th	13000	1.0	470	20	0.5	0.6	3100	59	130	240	33000	170	6700	280	0.77	0.6	95	0.2	46	12	79	170
25th	21000	12	1300	28	0.7	1.3	9000	66	280	670	40000	580	14000	650	2.2	1.5	160	0.2	200	13	86	320
50th	22000	20	2100	70	0.8	2.1	12000	83	350	940	42000	640	18000	700	4.7	1.7	240	0.24	220	14	120	620
75th	23000	70	3100	98	0.9	3	13000	87	440	1300	44000	860	19000	740	16.0	2.2	280	1.0	740	22	130	1900
95th	27000	140	13000	150	1.1	6	22000	95	2300	2100	60000	2200	21000	870	27	4	1300	1.0	1600	33	140	2400
Maximum	29000	150	15000	190	1.1	6	23000	96	3100	2100	60000	2400	22000	900	29	5	1900	1.0	1900	33	140	3000
Stations [1]	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Samples [2]	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	15	-	11	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	16	18	0	0	14	ns	12	18	18	ns	18	ns	ns	18	4	18	0	18	ns	12	17
Table 2 [5]	ns	12	18	0	0	0	ns	0	18	17	ns	15	ns	ns	6	0	14	0	18	ns	0	10

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.3.16.2: Summary of Chemical Analysis of Soil Samples from the Temiskaming Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	19000	8	470	10	0.3	0.2	19000	59	140	110	25000	33	12000	510	0.39	0.5	56	<0.2	51	11	83	40
5th	20000	9	560	11	0.3	0.2	21000	61	160	160	28000	73	13000	530	0.61	0.7	81	<0.2	65	11	88	93
25th	21000	14	820	13	0.5	0.5	22000	69	210	390	34000	200	17000	670	0.92	1.2	90	1.0	96	13	100	170
50th	22000	18	1200	15	0.6	0.7	25000	76	280	620	36000	280	19000	730	1.4	1.8	110	1.0	130	15	120	230
75th	25000	25	1700	18	0.8	0.9	28000	83	380	840	39000	410	20000	790	1.7	2.4	160	1.0	160	20	140	330
95th	29000	44	3500	21	0.9	1.5	30000	100	640	1300	46000	700	23000	890	3.0	4	230	1.0	300	23	160	440
Maximum	30000	250	4200	23	1.1	1.7	31000	120	890	1500	52000	930	27000	950	3.1	5	340	1.0	330	25	200	510
Stations [1]	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Samples [2]	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
OTR_{98} [3]	6	-	-	-	-	-	0	-	-	-	47	-	47	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	62	62	0	0	13	ns	41	62	62	ns	50	ns	ns	62	15	62	0	62	ns	54	47
Table 2 [5]	ns	47	62	0	0	0	ns	0	62	51	ns	46	ns	ns	0	0	17	0	62	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

The Temiskaming Mill is located approximately 300m to the east of the Silver Miller Mill and 300m to the southwest of the Beaver Mill. Both the Temiskaming Mill and Beaver Mill operated at the same time and were accessed via the same road. Between the Temiskaming Mill and the Beaver Mill is the location of the original Temiskaming Mine that was reopened in the 1970s as the Beaver and Temiskaming Mine. At the time of sampling, all that remained of the Temiskaming Mill were its concrete foundations. The tailings located to the south of the mill had been partially mined and reprocessed elsewhere. The area within the mill's foundations consisted of mill waste and some waste rock and was sparsely vegetated with rough bent grass. The area between the mill and the tailings was vegetated with grass and herbaceous weeds. Large ponds had formed on the east and west sides of the tailings as a result of the reprocessing activities. These pond areas had largely dried up at the time of sampling because of prolonged drought conditions and there was no vegetation growing on them. The tailings above the water line were predominately vegetated with arsenic tolerant rough bentgrass and Baltic rush.

Arsenic, cobalt, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty-four of the samples collected from the Temiskaming Mill. Antimony, copper, lead, mercury, nickel, and zinc exceeded the *Table 2 Generic* standard in 67%, 94%, 83%, 33%, 78%, and 56% of the samples respectively. Arsenic concentrations ranged from 400 to 15,000 µg/g with a median concentration of 2,100 µg/g. Concentrations of antimony, cobalt, copper, lead, nickel, silver, and zinc were moderately elevated around the mill site in comparison to other mill sites in the Cobalt-Coleman Mining Camp.

As would be expected, concentrations of arsenic and metals in the tailings were lower than those found in the mill waste. Only arsenic, cobalt, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all seventy-two of the samples collected from the Temiskaming tailings. Antimony, copper, lead, and nickel exceeded the *Table 2 Generic Standard* in 76%, 82%, 74%, and 27% of the samples respectively. Arsenic concentrations ranged from 470 to 4,200 µg/g, with a median concentration of 1,200 µg/g. The arsenic concentrations in the tailings were in the middle of the range typically found in medium grained tailings.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Temiskaming Mill and Tailings are presented in Appendix A, Maps A28.2 to A28.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentrations of arsenic and metals were found within the mill's foundations and in an outbuilding located 30 m to the east of the mill (station 591). Although there was no distinct spatial pattern of arsenic or metals in the Temiskaming Tailings, the highest concentrations of arsenic were found at stations 583 and 584 located at the outlet of an intermittent creek leading from the tailings area to the Cobalt Load Mine. There was no trend with any of the elements of decreasing or increasing concentration with depth in the tailings.

The results of the Pearson Correlations analysis on the mill sample results showed significant correlations between arsenic and cobalt, copper, iron, lead, manganese, mercury, nickel, and silver (refer to Table B30.a and Figures B30.a.1 to B30.1.6). Although the high results from station 576 influenced the significance of these correlations, the correlations still exist if this data is removed. The results of the Pearson Correlations analysis on the tailings results showed no significant correlations with arsenic (refer to Table B30.b and Figures B30.b.1 to B30.b6). The graphs of arsenic with antimony, cobalt, lead, mercury, nickel, and silver shows a trend of two distinct groups of data. The results from station 583 and 584 are distinctly different from the rest of the data.

4.3.17 Beaver Mill & Tailings

The Beaver Mill was located on the NE¼ of the N½ of Lot 1, Concession III, Coleman Township, 230 metres northeast of the Temiskaming Mill. The mill was built in 1911-1912. It was expanded to 90 tons per day in 1913 and to 120 to 150 tons per day in 1915. The mill closed in 1920. It reopened briefly from 1923 to 1924. The mill crushed the ore to 20 Mesh (0.85 mm) and the material was concentrated using a combination of wet gravity and flotation processes resulting in largely coarse sandy tailings.

The tailings were deposited into a valley on the Fisher Eplett property close to the mill. There was estimated to originally be 40,000 to 50,000 tons of tailings on the site. The tailings have migrated from their original location down a creek to the northwest corner of Kirk Lake. From Kirk Lake, the tailings have migrated along Kirk Creek to the south end of Crosswise Lake. There has been no mining of the tailings for reprocessing (the above background information is from Anderson, 1993).

Sampling at the Beaver Mill and Tailings was conducted on August 4th, 29th, and 30th, 2005. Eight samples were collected from three sampling locations at the mill site (refer to Maps A28.1, stations 599 to 601). Because of the varied nature of the mill site and the nature of the material being sampled, samples were collected with a corer in 10 cm increments to a depth of 30 cm from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 cores. Sixty samples were collected from ten sampling locations on the tailings (stations

602 to 612). Tailings samples were collected with a corer in 10 cm increments to a depth of 30 cm from 5 x 5 m areas. All tailings samples were composites of a minimum of 10 cores. All samples were collected in duplicate.

The results of the chemical analysis of the samples collected from the Beaver Mill and Tailings are given in Appendix C, Tables C34.a and C34.b. Table C34.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C34.b. Results in Table C34.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Beaver Mill and Beaver Tailings are given below in Table 4.3.17.1 and Table 4.3.17.1 respectively.

Table 4.3.17.1: Summary of Chemical Analysis of Soil Samples from Beaver Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	21000	7	470	12	0.4	0.2	18000	53	140	130	30000	54	14000	520	0.58	0.7	93	1.0	41	16	100	87
5th	21000	8	490	12	0.4	0.2	18000	53	150	130	30000	55	14000	520	0.59	0.7	95	1.0	48	16	100	89
25th	21000	10	550	13	0.4	0.2	20000	55	180	140	31000	57	15000	540	0.88	0.8	100	1.0	67	16	100	98
50th	22000	10	1400	17	0.4	0.4	21000	58	320	160	31000	92	15000	560	1.2	1.0	120	1.0	72	18	110	140
75th	24000	12	1800	20	0.5	0.6	21000	60	390	310	31000	110	16000	630	1.5	1.3	130	1.0	93	19	110	160
95th	25000	15	2600	37	0.5	0.7	22000	65	490	350	32000	130	16000	680	4.0	1.5	140	1.0	99	21	110	170
Maximum	25000	16	2700	44	0.5	0.7	22000	67	520	350	32000	130	16000	700	5.2	1.6	150	1.0	99	22	110	170
Stations [1]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	8	8	0	0	0	ns	0	8	8	ns	1	ns	ns	8	0	8	0	8	ns	8	1
Table 2 [5]	ns	1	8	0	0	0	ns	0	8	3	ns	0	ns	ns	0	0	0	0	8	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Table 4.3.17.2: Summary of Chemical Analysis of Soil Samples from the Beaver Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	19000	1.0	370	12	0.3	0.2	13000	44	100	90	28000	55	13000	490	0.38	<0.3	59	<0.2	26	13	92	83
5th	21000	2.3	420	13	0.4	0.2	17000	48	140	94	28000	69	14000	510	0.44	0.4	70	0.3	36	14	93	96
25th	22000	5	620	14	0.4	0.3	19000	64	170	180	32000	100	16000	590	0.78	0.7	87	1.0	50	15	100	120
50th	22000	8	890	16	0.5	0.5	21000	68	200	350	34000	140	17000	640	0.96	1.0	96	1.0	62	16	110	150
75th	24000	12	1200	18	0.6	1.4	23000	80	240	420	37000	220	17000	720	1.2	1.2	110	1.0	96	18	120	190
95th	26000	18	1700	21	0.7	1.8	27000	88	280	820	42000	410	19000	780	1.6	1.4	150	1.0	160	22	140	290
Maximum	28000	20	2000	24	0.7	2.1	31000	92	380	990	43000	550	19000	800	2.9	1.8	200	1.3	210	24	150	370
Stations [1]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Samples [2]	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	30	-	39	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	58	60	0	0	22	ns	24	60	60	ns	32	ns	ns	60	0	60	0	60	ns	60	24
Table 2 [5]	ns	10	60	0	0	0	ns	0	60	40	ns	18	ns	ns	0	0	3	0	60	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, all that remained of the Beaver Mill were its concrete foundations. A wood and metal sluice had recently been built on the foundations of the mill and it appears that tailings had been brought in to be processed through the sluice (refer to Figure 4.3.17.1). Visual observations and readings taken by the hand held XRF suggest that the main material within the mill's foundations was tailings and not mill waste. The mill area was sparsely vegetated with arsenic tolerant species and a few aspen and birch saplings. The tailings located to the east of

the mill consisted of two levels. The upper level to the west was largely unvegetated with small areas of Baltic rush, rough bentgrass and other arsenic tolerant species scattered throughout. The lower area to the east was damp and was dominated by Baltic rush.

Arsenic, cobalt, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all eight of the samples collected from the Beaver Mill. Antimony and copper exceeded the *Table 2 Generic* standard in 13% and 38% of the samples respectively. Arsenic concentrations ranged from 470 to 2,700 µg/g with a median concentration of 1,400 µg/g.

Figure 4.3.17.1: Beaver Mill (sluice)

Concentrations of arsenic, antimony, cobalt, copper, lead, nickel, silver, and zinc were lower than those at the nearby Temiskaming Mill, which were low in comparison to other mill sites in the Cobalt-Coleman Mining Camp.

Unlike other mill sites, the concentrations of arsenic and metals in the tailings were similar to those found at the mill site suggesting that the majority of the material in the mill was actually tailings (most likely brought in to run through the sluice that had been constructed). Only arsenic, cobalt, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all sixty of the samples collected from the Beaver tailings. Antimony, copper, lead and nickel exceeded the *Table 2 Generic Standard* in 17%, 67%, 30%, and 5% of the samples respectively. Arsenic concentrations ranged from 370 to 2,000 µg/g, with a median concentration of 1,200 µg/g. The arsenic concentrations in the tailings were in the middle of the range typically found in medium grained tailings and marginally lower than the nearby Temiskaming tailings.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Beaver Mill and Tailings are presented in Appendix A, Maps A28.2 to A28.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There was no clear pattern to the spatial distribution of any of the elements at the Beaver Mill and tailings. Given the narrow range in the concentrations found at this site, this was not unexpected. There was no trend with any of the elements of decreasing or increasing concentration with depth in the tailings data.

The results of the Pearson Correlations analysis on the mill sample results showed that the only significant correlation with arsenic was cobalt (refer to Table B31.a and Figures B31.a.1 to B31.a.6). There was no relationship of increasing concentrations with increasing arsenic concentration with all other elements. The Pearson Correlation analysis yielded no significant correlations with arsenic for the tailings sample results and there were very few correlations between other elements (refer to Table B31.b and Figures B31.b.1 to B31.b.6).

4.3.18 Beaver & Temiskaming Mine

The area between the Temiskaming Mill and Beaver Mill is referred to as the Beaver & Temiskaming Mine for the purposes of this report. These are the original locations of the Temiskaming mine shaft in the south and the Beaver mine shaft in the north. The Temiskaming mine shaft was reopened and operated in the 1970s. At the time of sampling, both headframes were gone, most of the buildings were removed, and only the concrete pads remained. One

building, near the winches of the new mine shaft, still existed. The whole area was covered with waste rock interspersed with small areas of tailings-like material around the Temiskaming mine shaft. A large mound of waste rock covers the Temiskaming shaft (refer to Figure D403 and D404). Vegetation was very sparse on the waste rock consisting of scattered birch saplings and some grass and herbaceous weeds.

Sampling at the Beaver & Temiskaming Mine was conducted on August 4th, 2005. Twenty-one samples were collected from ten sampling locations at the mill site (refer to Maps A28.1, stations 599 to 601). Because of the varied nature of the mine site and the nature of the material being sampled, samples were collected with either a trowel from 0 to 10cm or a corer in 10 cm increments to a depth of 30 cm from areas ranging in size from 1 x 1 m to 5 x 5 m. All samples were composites of a minimum of 10 trowel samples or 10 cores.

The results of the chemical analysis of the samples collected from Beaver & Temiskaming Mine are given in Appendix C, Tables C35.a and C35.b. Table C35.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C35.b. Results in Table C35.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.18.1 below.

Table 4.3.18.1: Summary of Chemical Analysis of Soil Samples from the Beaver and Temiskaming Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	12000	1.0	530	13	0.3	0.3	2400	44	150	130	27000	92	6400	250	0.27	0.4	52	1.0	19	9	81	120
5th	13000	1.0	570	13	0.3	0.4	3200	45	150	140	28000	93	6800	280	0.34	0.5	53	1.0	20	11	83	120
25th	20000	8	770	18	0.5	0.6	13000	71	200	460	37000	200	14000	660	1.3	1.2	110	1.0	120	12	93	150
50th	21000	15	2400	19	0.6	1.2	21000	75	420	660	39000	420	16000	700	3.3	1.7	230	1.0	190	17	100	340
75th	23000	38	5300	26	0.8	3	23000	83	650	840	46000	540	18000	790	6.6	4	440	1.0	350	23	130	810
95th	27000	140	13000	130	1.0	8	53000	150	1500	2000	120000	2300	19000	1200	25	7	600	1.0	1400	44	130	2700
Maximum	29000	150	15000	130	1.2	10	55000	150	1600	2200	130000	2400	20000	1200	27	7	710	1.7	1900	48	140	3300
Stations [1]	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Samples [2]	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
OTR_{98} [3]	1	-	-	-	-	-	0	-	-	-	18	-	8	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	19	21	0	0	12	ns	14	21	21	ns	17	ns	ns	21	10	21	0	21	ns	17	14
Table 2 [5]	ns	12	21	0	0	0	ns	0	21	19	ns	15	ns	ns	2	0	12	0	19	ns	0	7

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic and cobalt exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty-one of the samples collected from the Beaver and Temiskaming Mine. Antimony, copper, lead, mercury, nickel, and zinc exceeded the *Table 2 Generic Standard* in 57%, 90%, 71%, 10%, 57%, and 33% of the samples respectively. Arsenic concentrations ranged from 530 to 15,000 µg/g with a median concentration of 2,400 µg/g. Concentrations of arsenic, antimony, cobalt, copper, lead, nickel, silver, and zinc were higher than most mine sites in the Cobalt-Coleman Mining Camp.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Beaver & Temiskaming Mine are presented in Appendix A, Maps A28.2 to A28.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentrations were found at the

south end of the mine site in the tailings like material mixed in with the waste rock (stations 593 to 594). Concentrations in the waste rock were highest at the north end of the site around the old Beaver mine shaft in the rust coloured waste rock (stations 597 and 598).

The results of the Pearson Correlations analysis on the mill sample results showed that the only significant correlation with arsenic was manganese and molybdenum (refer to Table B32 and Figures B32.1 to B32.6). Although an timony was not correlated with arsenic it was significantly correlated with cobalt, mercury, and silver.

4.3.19 Kirk Lake Tailings

Some of the original tailings from the Beaver Tailings area have migrated down a fast flowing stream that drains the Beaver Tailings into a bay at the north end of Kirk Lake. The tailings cover an area of 3 hectares of the 30 hectare lake.

Sampling at the Kirk Lake tailings was conducted on July 25th, 2006. Fifteen samples were collected from five sampling locations within the tailings (refer to Maps A29.1, stations 785 to 789). Samples were collected with a corer at 0 to 10cm, 10 to 30cm, and 30 to 50cm depths from 5 x 5 m areas. All samples were composites of a minimum of 10 cores. At the time of the sampling, arsenic tolerant Baltic rush was the dominant vegetatio n found on the tailings, ranging from sparse cover near the lake to almost 100% cover by station 789. There were some signs of recent vehicle activity on the tailings.

The results of the chemical analysis of the samples collected from Kirk Lake tailings are given in Appendix C, Tables C36.a and C36.b. Table C36.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C36.b. Results in Table C36.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.19.1 below.

Only arsenic, cobalt, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all fifteen of the samples collected from the Kirk Lake tailings. Copper and nickel both exceeded the *Table 2 Generic Standard* in 7% of the samples. Arsenic concentrations ranged from 580 to 2,000 µg/g with a median concentration of 1,400 µg/g. The concentrations of arsenic and other metals in the tailings were in the middle of the range typically found in medium grained tailings and were very similar to the Beaver Tailings, which was expected given the origin of the Kirk Lake tailings.

Table 4.3.19.1: Summary of Chemical Analysis of Soil Samples from the Kirk Lake Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	19000	6	580	11	0.3	0.8	18000	57	140	110	29000	69	15000	540	0.41	<0.3	69	<0.2	27	14	94	99
5th	19000	7	750	11	0.3	0.8	19000	60	150	120	30000	77	15000	550	0.52	0.4	72	<0.2	27	14	95	110
25th	19000	8	980	12	0.4	0.9	20000	62	160	140	31000	92	16000	580	0.68	0.7	80	<0.2	34	15	100	120
50th	20000	9	1100	14	0.4	1.1	22000	64	190	170	31000	100	16000	600	0.78	0.9	93	<0.2	40	16	100	120
75th	21000	10	1400	14	0.4	1.2	23000	68	220	180	32000	110	16000	640	0.9	1.0	100	<0.2	60	17	110	130
95th	22000	12	1700	16	0.5	1.2	24000	75	270	240	33000	130	17000	680	1.4	1.2	130	<0.2	81	19	110	150
Maximum	22000	13	2000	17	0.5	1.3	24000	81	340	270	34000	130	18000	720	1.6	1.3	160	0.3	81	19	110	160
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	1	-	2	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	15	15	0	0	9	ns	2	15	15	ns	2	ns	ns	15	0	15	0	15	ns	15	0
Table 2 [5]	ns	0	15	0	0	0	ns	0	15	1	ns	0	ns	ns	0	0	1	0	15	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Kirk Lake tailings are presented in Appendix A, Maps A29.2 to A29.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There was no spatial pattern to any of the elements within the tailings. There was no trend with any of the elements of decreasing or increasing concentration with depth in the tailings data.

As with the Beaver Tailings, the results of the Pearson Correlation analysis yielded no significant correlations with arsenic and there were very few correlations between other elements (refer to Table B33 and Figures B33.1 to B33.6).

4.3.20 Cobalt Refinery (Hwy 11)

The Cobalt Refinery is located on Lot 13, Concession III, Coleman Township, along the Montreal River just south of the Highway 11 and 11B intersection. The refinery was built in 1949 by the Cobalt Chemical and Refining Company. It was rebuilt in 1954 and modified again in 1961 to recover silver, gold, bismuth, and lead. The refinery operated until 1968 when the mill was required to reduce arsenic emissions. Tailings were deposited in a tailings pond at the southwest corner of the refinery and covered an area of approximately 1.75 hectares. The tailings have been covered with two feet of sand and have largely naturally re-vegetated (the above background information is from Anderson, 1993).

Sampling at the Cobalt Refinery was conducted on June 7th, 2006. Twenty-two samples were collected from six sampling locations at the refinery site (refer to Maps A30.1). Single samples were collected with a corer at 0 to 20 cm, 20 to 40 cm, 40 to 60 cm and 60 to 70 cm depths taken from 5 x 5 m areas in the tailings. Duplicate 0 to 10 cm samples were collected from a drainage ditch at the southwest corner of the fenced refinery property. All samples were composites of a minimum of 10 cores.

The results of the chemical analysis of the samples collected from Cobalt Refinery are given in Appendix C, Tables C37.a and C37.b. Table C37.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C37.b. Results in Table C37.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a

summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.20.1 below.

Table 4.3.20.1: Summary of Chemical Analysis of Soil Samples from the Cobalt Refinery (Hwy 11)

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5700	0.2	4	13	0.2	0.2	1900	26	8	18	12000	6	2900	120	0.037	0.3	18	0.2	1	11	27	21
5th	5800	0.2	6	14	0.2	0.3	2000	26	11	19	13000	7	3300	120	0.043	0.3	19	0.2	1	13	28	23
25th	7500	0.8	170	24	0.2	0.6	2500	31	56	52	13000	24	4200	150	0.11	0.5	46	0.3	3	14	32	33
50th	9200	4.7	440	32	0.2	1.0	4800	34	94	130	14000	32	4700	170	0.57	1.8	80	1.0	7	17	36	44
75th	9700	9	2000	54	0.3	1.8	7700	37	320	400	18000	220	5500	210	1.6	4	200	1.0	48	20	41	68
95th	11000	23	3100	110	0.3	5	25000	74	1300	810	25000	740	7600	270	6.0	7	590	1.0	190	36	56	390
Maximum	11000	23	3800	130	0.3	30	27000	100	2100	1600	28000	890	9400	280	16	8	960	1.0	210	39	60	710
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	14	20	0	0	10	ns	2	19	15	ns	7	ns	ns	12	9	17	0	22	ns	0	5
Table 2 [5]	ns	4	20	0	0	1	ns	0	17	9	ns	6	ns	ns	1	0	7	0	9	ns	0	1

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling the refinery plant area was fenced off and not operating. Grass and horsetails were the dominant vegetation growing in the tailings area sampled. The grass cover ranged from no growth outside the western fence to sparse grass in the middle of the tailings area to 100 % cover along the west side of the tailings area. The areas south and east of the area sampled were well vegetated and included birch and aspen trees 5 to 20 cm diameter at breast height in size. The large berm that separated the refinery property from the Montreal River was intact and thickly vegetated.

Antimony, arsenic, cobalt, copper, lead, mercury, nickel, silver, and zinc exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in 18%, 91%, 77%, 41%, 27%, 5%, 32%, 41% ,and 5% of the samples respectively. Arsenic concentrations ranged from 4 to 3,800 µg/g with a median concentration of 440 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Cobalt Refinery are presented in Appendix A, Maps A30.2 to A30.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest surface concentrations of arsenic, in the 2000 µg/g range, were found at station 730 along the western fence where no vegetation was growing and at station 731 in the middle of the tailings area whi ch had only sparse vegetation cover. Surface arsenic concentrations were much lower at the other four sampling locations, ranging from 110 to 610 µg/g. Station 731 also had the highest concentrations of antimony, cobalt, lead, mercury, nickel, and silver with the other stations being significantly lower.

There was a complex pattern of concentration with depth at this site. At station 731, the concentrations of arsenic and most metals was high at all four depths, increasing to a maximum in the 20 to 40cm depth increment, decreasing in the 40 to 60 cm increment, followed by an increase in the 60 to 70 cm increment (refer to Figure 4.3.20.1). At the other sampling locations, arsenic, silver, and lead showed a similar pattern. At station 730 and 732 these elements were elevated at the surface and decreased with depth. At station 734 these elements were consistently low until the 60 to 70 cm increment where they increased, and at station 733 they were consistently low at all depths. For cobalt, copper, and nickel, stations 730, 732, 733 and 734 reported consistently low concentrations at all depths with only station 734 showing an increase in concentration at the 60 to 70 cm depth increment (refer to Figure 4.3.20.2). The depth pattern for antimony and mercury was similar to that of arsenic, lead, and silver at stations 730, 732 and 734. At station 733, antimony increased significantly below 20 cm as did mercury but to a lesser

extent than antimony (refer to Figure 4.3.20.3).

These depth profiles show that while the tailings pond at the Cobalt Refinery may have been buried under two feet of sand, concentrations of arsenic and metal at station 731, and to a lesser extent at station 730, show little indication of being covered. It should be noted that, visually, the material sampled at all of the locations in the tailings pond area had a similar sand-like appearance and did not look like the tailings normally found in the Cobalt-Coleman Mining Camp.

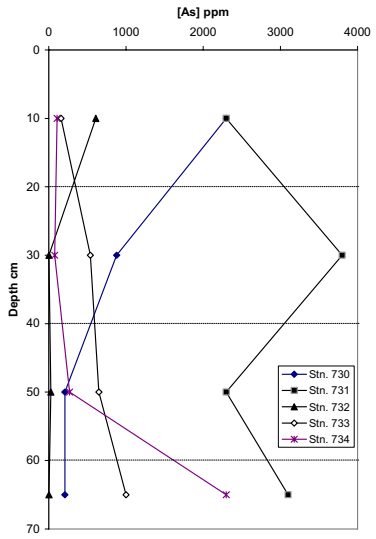


Figure 4.3.20.1: Arsenic depth profile.

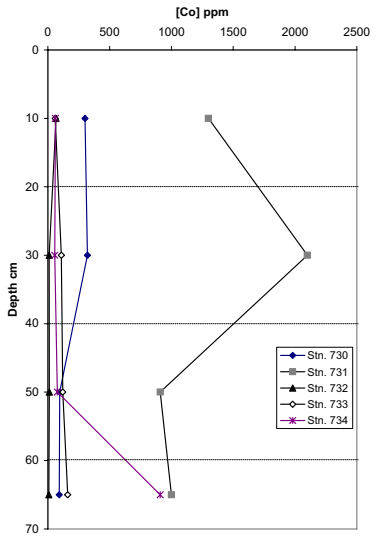


Figure 4.3.20.2: Cobalt depth profile.

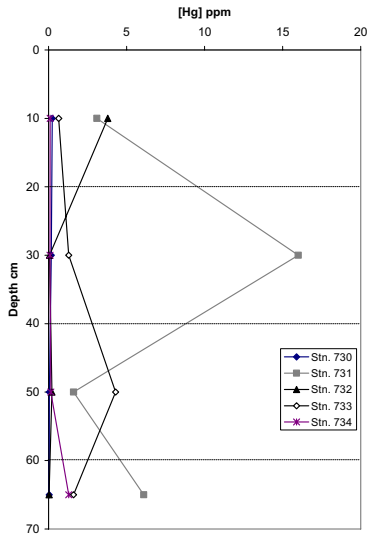


Figure 4.3.20.3: Mercury depth profile.

The results of the Pearson Correlations analysis showed significant relationships between arsenic, barium, chromium, cobalt, copper, iron, lead, nickel, silver, and zinc (refer to Table B34 and Figures B34.1 to B34.6). Although these relationships indicate a general trend of increasing metal concentrations with increasing arsenic concentration, there was a fair amount of scatter in the data at the lower concentrations and the high concentrations at station 731 were driving the correlations.

4.3.21 Hellen's Eplett Mine

The Hellen's Eplett Mine operated 1985 to 1988, and closed down when silver prices dropped. The property was purchased for the cobalt stockpiles on the site in the mid 1990's however the ore was taken to another mill for processing (Dawn Spires, MNDMF personal communications).

Sampling at the Hellen's Eplett Mine site was conducted on July 25, 2006. Eight samples were collected from four sampling locations (refer to Maps A31.1). Because of the varied nature of the mine site and the nature of the material being sampled, 0 to 5 cm trowel samples wer e taken from 1 x 1 m to 5 x 5 m areas. All samples were composites of a minimum of 10 trowel samples.

The results of the chemical analysis of the samples collected from Hellen's Eplett Mine are given in Appendix C, Tables C38.a and C38.b. Table C38.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted

in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C38.b. Results in Table C38.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.21.1 below.

Table 4.3.21.1: Summary of Chemical Analysis of Soil Samples from the Hellen's Eplett Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	22000	3	600	8	0.4	1.7	16000	72	170	230	32000	110	22000	460	0.2	1.1	73	<0.2	20	11	75	240
25th	24000	3	1200	10	0.7	3	17000	81	250	610	38000	640	23000	590	0.5	2.0	94	<0.2	40	16	87	640
50th	25000	10	2800	16	0.8	4	17000	84	580	770	41000	830	23000	660	1.7	2.1	140	0.3	110	19	96	940
75th	26000	21	5300	22	0.9	7	20000	100	1000	1200	50000	2200	25000	780	1.8	3	180	1.0	180	24	120	1900
Maximum	28000	51	7500	29	1.1	14	26000	130	1100	2400	53000	5400	29000	930	2.2	5	270	1.1	260	34	130	4100
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	2	-	-	-	-	-	0	-	-	-	6	-	8	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	8	8	0	0	8	ns	8	8	8	ns	6	ns	ns	7	2	8	0	8	ns	5	8
Table 2 [5]	ns	4	8	0	0	2	ns	0	8	8	ns	6	ns	ns	0	0	4	0	7	ns	0	6

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling there was very little left of the mine site. The tunnel entrance had been filled in with waste rock, only one building remained, and building debris was spread throughout the area. The whole area consisted of waste rock material with sparse vegetation growing on it. The total area occupied by the mine site was relatively small.

Arsenic, cobalt, and copper exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all eight of the samples collected from the Hellen's Eplett mine. Antimony, lead, nickel, silver, and zinc exceeded the *Table 2 Generic Standard* in 50%, 75%, 50%, 88%, and 75% of the samples respectively. Arsenic concentrations ranged from 600 to 7,500 µg/g with a median concentration of 2,800 µg/g. Concentrations of arsenic, antimony, cobalt, copper, lead, nickel, silver, and zinc were similar to other mine sites in the Cobalt-Coleman Mining Camp.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Hellen's Eplett Mine are presented in Appendix A, Maps A31.2 to A31.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The highest concentrations of arsenic and the other metals were found at station 793 located on what appeared to be a loading dock located at the beginning of the road leading to the mine. The second highest concentrations were found at the mouth of the tunnel (station 789) while the lowest concentrations were found up around the building.

The results of the Pearson Correlations analysis gave significant relationships between arsenic, antimony, cadmium, cobalt, copper, lead, molybdenum, nickel, silver, and zinc (refer to Table B35 and Figures B35.1 to B35.6).

4.3.22 Green-Meehan Mine, Mill and Tailings

The Green-Meehan Mill, also known as the Cobalt Contact Mine, was located in the SW ¼ of the N ½ of Lot 14, Concession I, Bucke Township. The mill and mine are located on the west side of Highway 567. The 60 to 100 ton per day mill was built in 1926 and operated until 1928. The tailings were discharged on the east side of Highway 567 and covered an area of approximately 4.2 hectares (the above background information is from Anderson, 1993).

Sampling at the Green-Meehan Mill, Mine and Tailings was conducted from June 6th to the 7th, 2006. Fourteen samples were collected from six sampling locations at the mill site (refer to Maps A32.1, stations 702 to 707). Because of the varied nature of the mill site and the nature of the material being sampled, samples were either 0 to 5 cm trowel samples or core samples taken at 10 cm increments to a depth of 20 cm from areas ranging in size from 1 x 1 m to 5 x 5 m. Eleven samples were collected from five sampling locations at the mine site (stations 708 to 712). Because of the varied nature of t he mine site and the nature of the material being sampled, samples were 0 to 5 cm trowel samples taken from 5 x 5 m areas. All samples were composites of a minimum of 10 trowel samples. Twenty-eight samples were collected from twelve sampling locations on the tailings (stations 713 to 724). Tailings samples were collected using a corer at 10 cm increments to a depth of 30 cm taken from 5 x 5 m areas. All tailing samples were composites of a minimum of 10 cores.

The Green-Meehan Mill is located approximately 30 metres west of Hwy 567 and at the time of sampling all that remained of the mill was its concrete foundations and some mill waste. The mill site was sparsely vegetated with rough bentgrass and small trees and shrubs. The main mine site was located uphill and immediately to the west of the mill. The headframe and other buildings were no longer present, the shaft filled with waste rock, and one area was fenced off as a mine hazard. There was a large amount of waste rock surrounding the mine. Very little vegetation was growing on the waste rock. A second mine shaft was located approximately 75 metres east of Hwy 567 adjacent to the tailings area. The shaft area was surrounded with waste rock and a large amount of garbage had been dumped in this area. The tailings extended approximately 300 metres east of the second mine shaft along a natural drainage course. The depth of the tailings was relatively shallow, often only 20 cm deep. The tailings were vegetated almost exclusively with Baltic rush that had formed a thick thatch layer over the tailings in most locations.

The results of the chemical analysis of the samples collected from Green-Meehan site are given in Appendix C, Tables C39.a and C39.b. Table C39.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C39.b. Results in Table C39.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Tables of summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Green-Meehan Mill, Mine and Tailings are given below in Tables 4.3.22.1, 4.3.22.2 and 4.3.22.3 respectively.

Table 4.3.22.1: Summary of Chemical Analysis of Soil Samples from Green Meehan Mill

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	18000	6	2500	7	0.6	2.1	9900	83	700	710	39000	260	12000	510	3.3	1.3	230	1.0	180	5	73	370
5th	19000	6	2700	7	0.6	2.1	11000	84	710	740	40000	290	13000	520	3.4	1.4	240	1.0	190	5	76	380
25th	20000	10	4100	8	0.8	2.3	15000	110	900	960	45000	470	21000	700	6	2.3	300	1.0	310	10	83	440
50th	24000	24	8400	18	0.9	4	22000	140	2000	2100	52000	1500	23000	1000	12	4	880	1.0	710	11	100	780
75th	28000	30	14000	50	1.2	4	24000	200	2700	3400	55000	1600	26000	1100	13	7	1200	1.0	870	15	140	1100
95th	29000	37	17000	230	3	5	25000	210	3500	4400	56000	2400	27000	1300	18	11	1400	1.3	970	320	140	1200
Maximum	29000	37	19000	250	3	5	26000	220	3600	4700	59000	3500	27000	1400	23	13	1500	1.4	1000	360	150	1400
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
OTR_{98} [3]	4	-	-	-	-	-	0	-	-	-	14	-	12	0	-	-	-	-	-	2	-	-
Table 1 [4]	ns	14	14	2	3	14	ns	14	14	14	ns	14	ns	ns	14	9	14	0	14	ns	10	14
Table 2 [5]	ns	10	14	0	3	0	ns	0	14	14	ns	14	ns	ns	8	0	14	0	14	ns	0	8

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic, cobalt, copper, lead, nickel and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all fourteen of the samples collected from the Green-Meehan Mill. Antimony, mercury, and zinc exceeded the *Table 2 Generic Standard* in 71%, 57%, and 57% of the samples respectively. Arsenic concentrations ranged from 2,500 to 19,000 µg/g with a median concentration of 24,000 µg/g. Concentrations of arsenic, antimony, cobalt, copper, lead, nickel, silver, and zinc were at the high end of the range for mill sites in the Cobalt-Coleman Mining Camp.

Table 4.3.22.2: Summary of Chemical Analysis of Soil Samples from the Green Meehan Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	7400	1.9	2300	8	0.8	2.7	6100	53	790	790	45000	290	5800	600	3.4	3	320	1.0	68	7	41	370
5th	7800	3	2400	8	0.8	2.7	7800	54	800	1000	46000	300	6600	660	3.4	4	340	1.0	76	7	42	420
25th	19000	8	5000	10	1.0	4	11000	68	1800	2000	53000	1000	18000	860	4.2	4	620	1.0	200	9	84	960
50th	24000	11	11000	20	1.2	7	15000	84	3700	2500	59000	2100	24000	1100	7.3	7	850	1.0	300	23	99	1800
75th	29000	38	20000	20	1.6	9	40000	140	6300	4400	73000	4600	26000	1200	9	8	1300	1.6	420	24	120	2600
95th	31000	56	22000	200	1.8	30	56000	160	7200	4600	100000	5400	28000	1600	13	10	1500	1.9	840	28	180	12000
Maximum	31000	57	25000	210	1.9	31	57000	160	7700	4900	110000	5400	29000	1600	14	12	1700	1.9	910	30	190	12000
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
OTR_{98} [3]	5	-	-	-	-	-	0	-	-	-	11	-	9	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	11	11	0	5	11	ns	8	11	11	ns	11	ns	ns	11	11	11	0	11	ns	7	11
Table 2 [5]	ns	4	11	0	5	2	ns	0	11	11	ns	11	ns	ns	2	0	11	0	11	ns	0	9

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic, cobalt, copper, lead, nickel, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all eight of the samples collected from the Green-Meehan Mine. Antimony, mercury and zinc exceeded the *Table 2 Generic Standard* in 36%, 18%, and 32% of the samples respectively. Arsenic concentrations ranged from 2,300 to 25,000 µg/g with a median concentration of 11,000 µg/g. Concentrations of arsenic, antimony, cobalt, copper, lead, nickel, silver, and zinc were at the high end of the range for mine sites in the Cobalt-Coleman Mining Camp.

Table 4.3.22.3: Summary of Chemical Analysis of Soil Samples from the Green Meehan Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	15000	2.2	840	3	0.4	0.8	11000	76	190	180	29000	86	17000	510	0.38	0.5	76	1.0	37	6	61	110
5th	18000	3	970	3	0.5	1.0	14000	92	200	200	34000	91	19000	580	0.51	0.7	81	1.0	41	7	74	130
25th	24000	4	1300	5	0.7	1.5	17000	130	340	400	46000	120	22000	980	0.9	1.5	190	1.0	54	8	110	200
50th	28000	5	2600	6	0.9	2.3	22000	160	790	850	52000	180	26000	1100	1.9	4	280	1.0	67	10	140	260
75th	32000	7	7100	9	1.2	3	31000	200	2100	2500	58000	450	41000	1300	2.9	8	400	1.0	130	16	160	540
95th	37000	11	10000	19	1.5	8	39000	220	3200	4100	94000	760	46000	1700	4.2	11	470	1.3	230	17	180	1500
Maximum	39000	12	12000	22	1.5	11	39000	220	3600	4800	120000	930	48000	1900	4.5	15	850	1.6	260	19	190	2100
Stations [1]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Samples [2]	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
OTR_{98} [3]	15	-	-	-	-	-	0	-	-	-	26	-	28	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	28	28	0	7	25	ns	28	28	28	ns	20	ns	ns	28	19	28	0	28	ns	23	25
Table 2 [5]	ns	0	28	0	7	0	ns	0	28	25	ns	13	ns	ns	0	0	21	0	28	ns	0	5

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic, cobalt, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all eight of the samples collected from the Green-Meehan tailings. Copper, lead, nickel, and zinc exceeded the *Table 2 Generic Standard* in 89%, 46%, 75%, and 18% of the samples respectively. Arsenic concentrations ranged from 840 to 12,000 µg/g with a median concentration of 2,600 µg/g. Concentrations of arsenic and to a lesser extent cobalt, copper, lead, nickel, silver, and zinc were at the high end of the range for tailings sites in the Cobalt-Coleman Mining Camp.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel and silver at the Green-Meehan Mine, Mill and Tailings are presented in Appendix A, Maps A32.2 to A32.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There is no distinct spatial distribution to arsenic or the other metals within the mill or main mine site. Concentrations of antimony, mercury, and silver were marginally lower at the mine site compared to the mill site however for arsenic and other metals there was very little difference between the two sites. There was a distinct spatial pattern in the tailings area for arsenic and cobalt. Concentrations of these elements were much higher at stations 713, 714, 715, 716,717 and 720 along the southeast side of the tailings in comparison to the other stations along the west side and north end of the tailings.

At the tailing area stations, where the tailings were deep enough to obtain two or more depth increments, there was a trend of increasing concentration with increased depth for arsenic, cobalt and nickel. The highest concentrations were normally found in the 10 to 20 cm depth increments (refer to Figure 4.3.22.1). This trend was strongest in the south eastern side of the tailings where the highest concentrations of these elements were also found. The other elements did not show this trend.

The results of the Pearson Correlations analysis of the mill results showed significant correlations between arsenic, cadmium, cobalt, nickel, silver and to a lesser extent copper (refer to Table B36.b and Figures B36.a.1 to B36.a.6). Although lead and mercury were not significantly correlated with arsenic, concentrations of these elements showed a trend of increasing concentration with increasing arsenic concentration.

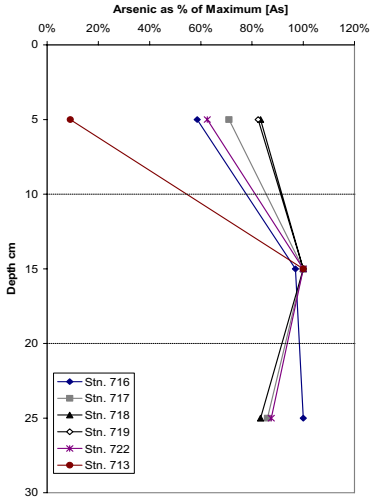


Figure 4.3.22.1: As Depth Profiles

At the main mine site, significant correlations were only observed for arsenic with antimony and cobalt (refer to Table B36.b and Figures B36.b.1 to B36. b.6). Although the concentration of mercury, nickel and silver tended to increase with increases in arsenic concentrations, the highest concentrations of lead were found at sites with the lowest concentrations of arsenic. There were a large number of significant correlations for the tailings area (refer to Table B36.c and Figures B36.c.1 to B36.c.6). Arsenic was significantly correlated with beryllium, cobalt, magnesium, and strontium and to a lesser degree with aluminum, calcium, copper, manganese, molybdenum, and vanadium. Aluminum also had a large number of significant correlations. These correlations indicate that the tailings were all from the same ore body. The graphs of the relationships of arsenic with lead, mercury, and silver show that there were two distinct populations within the data. One population consists of the results from the sampling locations along the southeast side of the tailings which were characterized by high concentrations of arsenic.

4.3.23 Teledyne Professor Mine

The Teledyne Professor Mine is located on Lot 15, Concession 1, Bucke Township, off the Bucke Park Road. The claims were optioned to Teledyne Canada Ltd. by Consolidated Professor Mines Ltd. Between 1979-81 a decline ramp was driven 2800 fee t into the ground (MNDMF, Abandoned Mines Info System). At the time of sampling, the mine was closed, all buildings had been removed and only the concrete building pads remained.

Sampling at the Teledyne Professor Mine site was conducted on June 7th, 2006. Ten samples were collected from five sampling locations (refer to Maps A33.1). Because of the varied nature of the mine site and the nature of the material being sampled, samples were 0 to 5 cm trowel samples taken from 1 x 1 m to 5 x 5 m areas. All samples were composites of a minimum of 10 trowel samples.

The results of the chemical analysis of the samples collected from the Teledyne Professor site are given in Appendix C, Tables C39.a and C39.b. Table C39.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C39.b. Results in Table C39.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.23.1 below.

Table 4.3.23.1: Summary of Chemical Analysis of Soil Samples from the Teledyne Professor Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	8800	0.2	13	6	0.2	0.66	700	46	17	22	20000	8	10000	180	0.008	0.6	34	<0.2	1	16	44	42
25th	14000	0.2	24	22	0.3	0.75	10000	64	28	60	23000	12	13000	280	0.012	0.7	35	<0.2	1	19	48	50
50th	18000	0.2	63	28	0.4	1.3	15000	79	38	130	36000	16	16000	370	0.022	0.9	38	<0.2	1	32	66	55
75th	23000	0.2	96	68	0.6	1.7	22000	85	48	300	44000	22	24000	420	0.035	5	80	<0.2	2	40	110	78
Maximum	25000	3	4200	99	1.4	4	32000	120	60	660	150000	470	36000	640	0.22	9	84	2.2	68	53	150	110
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	6	-	4	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	2	9	0	2	6	ns	6	8	6	ns	2	ns	ns	0	4	4	2	10	ns	4	0
Table 2 [5]	ns	0	8	0	2	0	ns	0	4	3	ns	2	ns	ns	0	0	0	0	2	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, the Teledyne Professor site had been decommissioned and largely cleaned up. There was a steel door on the mine entrance, all buildings had been removed, and there were two areas of waste rock material. One waste rock area was immediately adjacent to the mine shaft, while the other waste rock area was located on the north side of the mine road half way between the mine entrance and Bucke Park Road.

Arsenic, cobalt, copper, lead, and silver exceeded both of the O. Reg. 153-04 Table 1 Background and Table 2 Generic soil standards in 80%, 20%, 40%, 30%, 20%, and 20% of the samples respectively. Arsenic concentrations ranged from 13 to 4,200 µg/g with a median concentration of 63 µg/g. Concentrations of arsenic and metals at the Teledyne Professor Mine were the lowest found at a mine site in the Cobalt-Coleman Mining Camp.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at the Teledyne Professor Mine are presented in Appendix A, Maps A33.2 to A33.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The only location with high arsenic and metal concentrations was station 725 located on the north side of the mine road opposite the building pad where there was a small area of rust-coloured fine material.

The results of the Pearson Correlations analysis showed that there were a large number of highly significant correlations in the mine site data (refer to Table B37 and Figures B37.1 to B37.6). Arsenic was significantly correlated with antimony, cadmium, copper, iron, lead, mercury, molybdenum, selenium, silver, and vanadium. The graphs of arsenic with antimony, cobalt, lead, mercury, nickel, and silver clearly show that these highly significant correlations are entirely due to the influence of the high concentrations found at station 725.

4.3.24 Agaunico Mine

The Agaunico Mine is located on the western shore of Lake Temiskaming immediately north of the Bucke Park campground. Work was undertaken on this property before 1922. There has been no production at the property since 1960. The mine shaft was capped in approximately 1990 (Dawn Spires, MNDMF personal communications).

Sampling at the Agaunico Mine site was conducted on June 8th, 2006. Twelve samples were collected from six sampling locations (refer to Maps A31.1). Because of the varied nature of the mine site and the nature of the material being sampled, samples were 0 to 5 cm trowel samples taken from 1 x 1 m to 5 x 5 m areas. All samples were composites of a minimum of 10 trowel samples.

The results of the chemical analysis of the samples collected from Agaunico Mine are given in Appendix C, Tables C41.a and C41.b. Table C41.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C41.b. Results in Table C41.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.24.1 below.

Table 4.3.24.1: Summary of Chemical Analysis of Soil Samples from the Agaunico Mine

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	17000	1.0	1300	5	0.3	1.3	1900	74	210	600	38000	45	11000	230	0.084	3	130	0.3	3	12	70	110
5th	18000	1.1	1500	5	0.4	1.4	2000	74	290	690	41000	65	12000	240	0.087	4	180	0.7	4	13	70	120
25th	25000	1.4	3300	18	0.8	2.4	7300	100	740	840	48000	140	16000	500	0.14	6	400	1.0	8	13	91	180
50th	30000	3	4400	32	1.3	3	9000	120	1600	980	49000	240	26000	580	0.30	8	740	1.0	14	22	100	330
75th	35000	5	9200	46	1.4	4	11000	280	4000	1100	120000	420	32000	610	0.43	17	1500	1.0	30	32	120	460
95th	36000	15	19000	58	1.6	4	19000	460	6600	1900	130000	550	47000	650	0.63	33	5000	2.4	95	33	130	600
Maximum	37000	26	24000	61	1.7	4	24000	470	9500	2000	130000	580	48000	660	0.70	36	7000	3	110	34	140	630
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
OTR_{98} [3]	8	-	-	-	-	-	0	-	-	-	12	-	8	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	11	12	0	7	12	ns	12	12	12	ns	9	ns	ns	7	12	12	1	12	ns	8	10
Table 2 [5]	ns	1	12	0	7	0	ns	0	12	12	ns	6	ns	ns	0	0	11	0	4	ns	0	1

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

At the time of sampling, the mine shaft located near the top of a steep hill overlooking Lake Temiskaming was filled with waste rock and there were only a few timbers remaining. The mine shaft was surrounded by a large waste rock dump that extended from the top of the hill to the water's edge. The waste rock in the dump was largely grey in colour with areas of rust stained waste rock scattered randomly throughout the dump. There were scattered patches of sparsely growing herbaceous weeds and grass growing on the level areas of the waste rock dump and no vegetation growing on the slopes. The mine site was immediately adjacent to the Bucke Park trailer camp parking area by the main office building and there was evidence of regular human activity at the site.

Arsenic, copper, and cobalt exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twelve of the samples collected from the Agaunico Mine site. Antimony, lead, nickel, silver, and zinc exceeded the *Table 2 Generic Standard* in 8%, 50%, 92%, 33%, and 8% of the samples respectively. Arsenic concentrations ranged from 1,300 to 24,000 µg/g with a median concentration of 4,400 µg/g. Concentrations of arsenic and cobalt were at the high end of the range for mine sites in the Cobalt-Coleman Mining Camp area while the other metals were at more typical concentrations.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Agaunico Mine are presented in Appendix A, Maps A33.2 to A33.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There was no pattern to the spatial distribution of arsenic or the other metals as the highest concentrations were found in the randomly scattered rust stained waste rock.

The results of the Pearson Correlations analysis show arsenic significantly correlated with antimony, cobalt, mercury, nickel, and silver (refer to Table B38 and Figures B38.1 to B38.6). Although arsenic was significantly correlated with these elements, the graphs of these relationships show a significant amount of scatter in the data. There were few other significant correlations between other elements.

4.3.25 Mill Creek Tailings

Tailings from both Cobalt Lake and the Nipissing Low Grade Tailings area have migrated into Mill Creek at this location. During sampling of the Right-of-Way Mine (HST Site 9) a number of children were observed playing in an area of bare tailings along Mill Creek just north of the HST Site 9 parking lot.

Sampling at the Mill Creek Tailing was conducted on August 19th, 2004. Sixteen samples were

collected from two sampling locations (refer to Maps A37.1, stations 258 and 259). Tailings samples were collected with a corer at 0 to 10 cm, 10 to 20 cm, 20 to 30cm, and 30 to 35 cm depths taken from 5 x 5 m areas. All tailing samples were collected in duplicate and were composites of a minimum of 10 cores. At the time of sampling the surface of the tailings was dry and covered with a pink crust. Numerous child-sized footprints, bike tire tracks and dog prints were observed on the tailings. There was no vegetation growing on the tailings in the area that was sampled.

The results of the chemical analysis of the samples collected from Mill Creek Tailings are given in Appendix C, Tables C42.a and C42.b. Table C42.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C42.b. Results in Table C42.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.3.25.1 below.

Table 4.3.25.1: Summary of Chemical Analysis of Soil Samples from the Mill Creek Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	20000	33.0	3300	6	0.7	0.54	16000	86	880	500	36000	180	19000	590	10	2	580	0.2	43	11	93	210
5th	20000	34	3400	6	0.7	0.57	17000	88	890	510	36000	180	20000	590	10	2	590	0.2	44	11	93	210
25th	20000	40	3500	6	0.7	0.63	17000	89	970	520	36000	180	20000	600	11	2	610	0.2	47	11	94	210
50th	20000	43	3600	7	0.76	1	17000	91	980	520	36000	190	20000	600	12.00	2.2	640	0.2	54	12	95	210
75th	20000	50	3600	8	0.76	1	17000	93	1000	530	36000	190	20000	610	12.00	2.4	640	0.2	55	12	95	220
95th	21000	55	3800	8	0.79	1	17000	96	1000	540	37000	200	20000	620	13.00	2.6	660	0.2	71	13	97	220
Maximum	21000	56	3900	8	0.79	0.82	18000	100	1000	550	37000	200	20000	620	14.00	2.6	660	0	74	13	97	220
Stations [1]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Samples [2]	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	16	-	16	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	16	16	0	0	0	ns	16	16	16	ns	16	ns	ns	16	3	16	0	16	ns	16	16
Table 2 [5]	ns	16	16	0	0	0	ns	0	16	16	ns	0	ns	ns	14	0	16	0	16	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Antimony, arsenic, cobalt, copper, nickel, and silver exceeded both of the *O. Reg. 153-04* Table 1 Background and Table 2 Generic soil standards in all sixteen of the samples collected from the Mill Creek tailings. Mercury exceeded the Table 2 Generic standard in 78% of the samples. Arsenic concentrations ranged from 3,300 to 3,900 µg/g with a median concentration of 3,600 µg/g. Concentrations of all of the elements were very similar to the Nipissing Low Grade Tailings (refer to Figure 4.3.25). Given that the sampling locations in Mill Creek were just below the confluence of drainage from the Nipissing Low Grade Tailings and Mill Creek, and the similarity in the median concentration results between the two sites, it can be concluded that the tailings sampled in Mill Creek originated from the Nipissing Tailings and not Cobalt Lake.

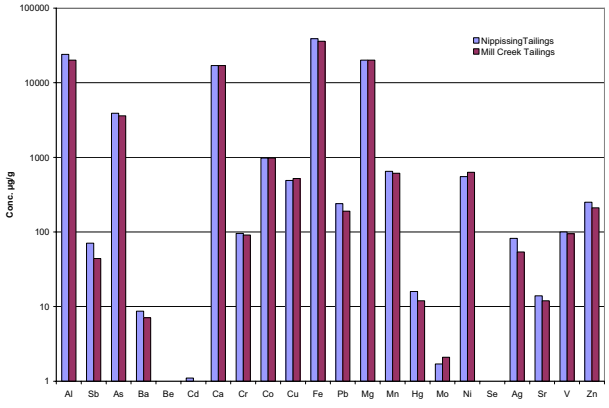


Figure 4.3.25: Median concentrations at the 2 locations.

The results of the Pearson Correlations analysis showed no significant correlation between any elements in the samples from Mill Creek (refer to Table B39 and Figures B39.1 to B39.6). This is due to the very small range in concentrations for all the elements at all depths. There was no change in concentration for any of the elements with depth.

4.4 Schools, Parks and Green Spaces

4.4.1 Cobalt Coleman Public School

The Cobalt Coleman Public School is located at 5 Dunning Drive in Cobalt. The school is built on top of part of the Buffalo Mill tailings. The tailings are covered with approximately six inches of gravel, sand mixed with stones and rocks similar to glacial till, and approximately six inches of topsoil (Anderson, 1993).

Sampling at the Cobalt Coleman Public School tailing was conducted on July 13th, 2006. Eleven samples were collected from five sampling locations (refer to Maps A35.1). Soil samples were collected with a corer taken from 5 x 5 m areas. Because of the varied thickness of topsoil over the pit run cover material, sample depths varied from 20 cm to 40 cm, with the first sample depth being 0 to 5 cm, followed by 10 cm increments. All samples were composites of a minimum of 10 cores.

At the time of sampling the playground field was grassed with a bare area in front of the baseball backstop. All sampling was conducted within the school playground area and no samples were taken from the area behind the school where a gravel parking lot and an area of waste rock covered tailings were located. No attempt was made to sample below the gravel layer covering the tailings as the purpose of sampling was to determine the degree of contamination at depths at which children playing in the school ground would be expected to be exposed to through normal activities.

The results of the chemical analysis of the samples collected from Cobalt Coleman Public School are given in Appendix C, Tables C43.a and C43.b. Table C43.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C43.b. Results in Table C43.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.4.1 below.

Table 4.4.1: Summary of Chemical Analysis of Soil Samples from the Cobalt Coleman Public School

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	6100	0.2	3	16	0.18	0.2	3900	26	7	16	9800	5	4200	170	0.007	0.3	16	0.2	1	15	21	21
5th	6200	0.2	3	16	0.18	0.22	4000	27	8	16	11000	5	4400	170	0.007	0.3	18	0.2	1	16	24	22
25th	6400	0.2	7	18	0.19	0.29	4600	28	9	19	13000	6	5000	180	0.007	0.3	19	0.2	1	18	32	26
50th	7600	0.38	9	22	0.23	0.41	7800	32	11	22	14000	8	5400	200	0.047	0.3	22	0.2	1	18	34	30
75th	10000	0.68	20	50	0.32	0.47	14000	40	14	26	15000	15	6400	280	0.083	0.3	28	0.32	2	34	36	46
95th	12000	2.7	62	62	0.4	0.62	20000	44	23	46	16000	18	8400	320	0.22	0.3	33	0.54	13	41	38	53
Maximum	13000	3.8	100	65	0.45	0.67	23000	47	28	53	17000	18	9900	340	0.27	0.3	35	0.65	18	44	38	54
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	2	4	0	0	0	ns	0	1	0	ns	0	ns	ns	1	0	0	0	11	ns	0	0
Table 2 [5]	ns	0	3	0	0	0	ns	0	0	0	ns	0	ns	ns	0	0	0	0	0	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic was the only element to exceed *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards with three of the eleven samples exceeding the *Table 2* standard of 20 µg/g. Of the few exceedances of the *Table 1 Background Standards*, antimony was exceeded in 18% of the samples, arsenic in 36%, cobalt in 9%, mercury in 9%, and silver in 100% of the samples. The silver exceedances were the result of the detection limits for silver analysis (1.0 µg/g) that were greater than the Table 1 standard of 0.47 µg/g and were not due to contamination by local mining activities. Arsenic concentrations ranged from 3 to 100 µg/g with a median concentration of 9 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver at the Cobalt Coleman Public School are presented in Appendix A, Maps A35.2 to A35.8 respectively. The concentration of each sample at each sampling location is represented by a dot, the larger and darker the dot the higher the concentration.

There has been little impact to Cobalt-Coleman School's school yard soil by local mining activities because of the nature of the clean soil brought in to cover the school yard.

4.4.2 St. Patricks Catholic School

St. Patrick's Catholic School is located on the southeast corner of Ferland and Lang Streets in Cobalt. The current school was built in 1984. The school playground and field are located on the east side of the school overlooking the Ontario Northland Railway rail line and the Right-of-Way Mine. The school yard was built into the side of a hill and a large retaining wall is located on the east side of the school yard. Approximately two metres of clean top soil was brought in and placed behind the retaining wall to form a level field during the construction of the school yard (personal communications with school staff).

Sampling at St. Patrick's Catholic School was conducted on July 12th, 2006. Twenty samples were collected from five sampling locations (refer to Maps A36.1). Soil samples were collected with a corer at 0 to 5 cm, 5 to 20 cm, 20 to 40 cm, and 40 to 60 cm depths taken from 5 x 5 m areas. All samples were composites of a minimum of 10 cores. At the time of sampling, the play field was covered in grass with bare areas in front of the soccer goal posts.

The results of the chemical analysis of the samples collected from St. Patrick Catholic School are given in Appendix C, Tables C44.a and C44.b. Table C44.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont.*

Reg. 153-04 are given in Table C44.b. Results in Table C44.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.4.2 below.

Table 4.4.2: Summary of Chemical Analysis of Soil Samples from the St. Partrick Catholic Public School

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5100	0.2	1	14	0.15	0.2	2400	20	5	12	8100	4	3000	130	0.007	0.3	15	0.2	1	14	19	17
5th	5100	0.2	1	14	0.15	0.2	2500	20	5	13	8200	4	3000	140	0.007	0.3	15	0.2	1	14	20	18
25th	5400	0.2	1	15	0.16	0.2	3200	24	7	14	11000	5	3900	140	0.007	0.3	15	0.2	1	16	25	18
50th	5600	0.2	1	18	0.17	0.2	4000	28	7	14	12000	5	4000	150	0.007	0.55	18	0.2	1	19	29	20
75th	6700	0.2	1	26	0.2	0.22	8000	34	7	17	12000	6	4800	170	0.007	0.8	22	0.2	1	30	30	24
95th	14000	0.61	2	65	0.35	0.25	20000	56	11	23	18000	9	11000	350	0.0079	1.8	30	0.27	1	43	42	47
Maximum	15000	0.75	2	71	0.37	0.25	24000	58	12	23	19000	9	13000	370	0.013	2.1	31	0.28	1	49	42	60
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	0	0	0	0	0	ns	0	0	0	ns	0	ns	ns	0	0	0	0	20	ns	0	0
Table 2 [5]	ns	0	0	0	0	0	ns	0	0	0	ns	0	ns	ns	0	0	0	0	0	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

There were no exceedances of the *O. Reg. 153-04 Table 2 Generic* soil standards in all twenty of the samples collected at St. Patrick Catholic School. The only exceedances of the *O. Reg. 153-04 Table 1 Background Standards* occurred for silver where all samples exceeded the standard. These exceedances were the result of the detection limits for the silver analysis (1.0 µg/g) being greater than the Table 1 standard of 0.47 µg/g and were not due to contamination by local mining activities.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver at St. Patrick Catholic School are presented in Appendix A, Maps A36.2 to A36.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The spatial distribution consisted of a uniform distribution of background concentrations for all elements, both spatially and with depth.

There has been no impact to St. Patrick's Catholic School's school yard soil by local mining activities because of the clean nature of the soil brought in to build the school yard.

4.4.3 Cobalt Lake - Green Spaces

Cobalt Lake is located in the heart of the Cobalt area with the Town of Cobalt located on its western shore and the main residential area of Coleman Township located on its eastern shore. The Ontario Northland Railway rail line runs along the western shore of the lake. The lake is approximately 1.5 km long, averaging approximately 0.15 km in width, and extends in a southwest to northeast direction. The lake is divided into two sections by a man-made peninsula built on the east side of the lake. The southern section of the lake is approximately 11.5 hectares in area while the northern section is approximately 6.1 hectares in area.

During Cobalt's mining heyday, the lake was surrounded by mines and mills. There were four mills that used the lake for tailings deposition, including: the Cobalt Reduction Mill, the McKinley-Darragh Mill, the Cobalt Lake Mill, and the Nipissing High Grade Mill. The lake was drained on three separate occasions to mine and reprocess the tailings. The last draining and mining of the lake occurred in the 1960s at which time the tailings were processed at the Hellens Mill (established on the Cobalt Lake Mill foundations). Tailings from this operation were

deposited on the east side of the lake forming the peninsula where a baseball field and the Lion's Club Park are now located. This area of tailings was extended and covered with rock from construction activities following a fire in 1977, and in 1983, was covered with clean fill and the new park built. There is a second smaller peninsula of tailings on the west side of the lake approximately 100 m from the eastern peninsula.

The southern half of the lake is largely undeveloped and includes abandoned mining and milling sites along the shore. The northern end of the lake has been turned into a series of parks and green spaces. The baseball field, soccer field and the Lion's Club playground are the dominant green spaces on the lake and the results of sampling from these areas are discussed in Section 4.4.5 below. A walking trail extends from the north end of the soccer field, over Mill Creek, and around the top of the lake to the railway tracks. There is a continuous green space along the western shore of the lake starting at the north end at Heritage Silver Trail Site 20, including Jack Koza Park to south of the railway station at the bridge across the narrows, extending to the ball field and the Lion's Club Playground. Sampling results from the walking trail, the western shore green space, and the small peninsula on the west side of the lake are discussed in this section.

Initial sampling of green spaces around Cobalt Lake that are regularly accessed by the public was conducted on July 14th, 2005. Samples of exposed tailings were collected from the smaller western peninsula, the east side of the pedestrian bridge across the lake, and the shore line south of the Lion's Club playground (refer to Maps A37.1, stations 568 to 572). Twenty-two samples were collected from the five samplings sites. Soil samples were collected with a corer at 0 to 5 cm and 5 to 15 cm depths from areas ranging in size from 1 x 1m to 5 x 5 m. At the time of sampling there was little vegetation growing on the tailings and child-sized foot prints were observed in the tailings.

The second set of sampling of green spaces around Cobalt Lake was conducted on July 11th and 12th, 2006. Seventeen samples were collected from six sampling locations along the western shore of Cobalt Lake (stations 742 to 747). Soil samples were collected with a corer at 0 to 5 cm, 5 to 15 cm, and where possible, 15 to 25 cm depths from 5 x 5 m areas. All of the sampling locations were vegetated with grass. Eight samples were taken from four sampling locations along the walking trail at the north end of the lake (stations 758 to 761). Soil samples were collected with a trowel at 0 to 5 cm depth from 1 x 5 m areas along the path. All samples were composites of a minimum of 10 trowel samples. At the time of sampling the trail was surfaced with gravel interspersed with sparse vegetation and was vegetated with grass and native herbaceous flowers on either side.

The results of the chemical analysis of the samples collected from the Cobalt Lake parks and green spaces are given in Appendix C, Tables C45.a and C45.b. Table C45.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C45.b. Results in Table C45.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceed the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines for the Cobalt Lake tailings, western shore green spaces, and the walking trail are given below in Tables 4.4.3.1, 4.4.3.2 and 4.4.3.3 respectively.

Table 4.4.3.1: Summary of Chemical Analysis of Soil Samples from the Cobalt Lake Green Spaces - Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	19000	0.31	370	5	0.72	0.2	8700	93	140	70	33000	39	16000	460	1.7	0.79	96	0.2	27	7	82	58
5th	19000	0.91	410	5	0.72	0.2	8900	93	140	86	33000	45	16000	460	2	0.84	100	0.2	34	7	83	66
25th	19000	3.7	520	5	0.76	0.37	9800	100	160	93	34000	78	17000	490	2.8	1	100	0.2	42	7	85	82
50th	20000	5.7	640	7	0.8	0.53	12000	100	340	98	35000	85	18000	540	3.6	1.5	220	0.2	48	9	87	96
75th	21000	8.2	1800	8	0.86	0.6	15000	110	690	120	36000	91	18000	590	4	2.8	380	1	54	10	89	110
95th	21000	14	2900	9	0.93	0.67	17000	140	1200	160	37000	110	19000	620	8.1	6	670	1	63	11	92	130
Maximum	21000	15	3100	10	0.95	0.78	17000	160	1700	200	38000	110	20000	680	10	12	880	1	120	11	96	140
Stations [1]	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Samples [2]	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	20	-	19	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	20	22	0	0	0	ns	22	22	21	ns	0	ns	ns	22	7	22	0	22	ns	2	0
Table 2 [5]	ns	5	22	0	0	0	ns	0	22	0	ns	0	ns	ns	0	0	12	0	22	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

As would be expected, there were a significant number of exceedances of the *O. Reg. 153-04 Table 2 Generic* soil standards in the areas of exposed tailings around Cobalt Lake. Arsenic, cobalt, copper, nickel, and silver exceeded both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty-two of the samples collected. Antimony and nickel exceeded the *Table 2 Generic Standard* in 23% and 55% of the samples respectively. Arsenic concentrations ranged from 370 to 3,100 µg/g with a median concentration of 640 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver around Cobalt Lake are presented in Appendix A, Maps A37.2 to A37.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. There is a distinct pattern to the arsenic and metals concentrations found in the tailings samples. At stations 570 and 571, on the small western peninsula, where children had been observed swimming in the past, the tailings were of a medium to coarse grained texture and arsenic concentrations ranged from 370 to 590 µg/g. At stations 568 and 569, located just north of the pedestrian bridge to the baseball field, exposed medium to fine grained tailings had arsenic concentrations that were much higher, ranging from 560 to 2,900 µg/g. At these locations there was an area of exposed tailings along the channel between the north and south portions of the lake. These tailings were deposited by the Hellen's Mill in the 1960s forming the eastern peninsula and were subsequently covered with rock and clean soil to create the baseball field and park. The tailings along the eastern shore just south of the Lion's Club playground along a foot path (station 572) had similar concentrations to stations 568 and 569.

The results of the Pearson Correlations analysis showed significant correlations between arsenic and antimony, copper, cobalt, manganese, and nickel in the samples from the Cobalt Lake tailings (refer to Table B42.a and Figures B42.a.1 to B42.a.6).

Table 4.4.3.2: Summary of Chemical Analysis of Soil Samples from the Cobalt Lake Green Spaces - Western Shore

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	6300	0.26	17	31	0.23	0.56	3200	30	12	38	13000	17	4300	230	0.069	0.52	21	0.2	1	20	24	42
5th	6500	0.49	21	31	0.25	0.57	3400	32	14	49	15000	20	4400	240	0.07	0.69	23	0.2	1	20	24	48
25th	7000	1.1	74	34	0.3	0.74	5600	35	26	64	16000	68	4800	260	0.28	0.89	32	0.31	4	22	31	86
50th	7800	2.4	100	42	0.33	0.81	11000	40	30	82	18000	84	5300	270	0.57	1.1	36	0.38	6	25	34	110
75th	8200	2.7	180	48	0.4	0.93	12000	41	45	93	24000	140	6100	300	0.72	1.8	46	0.57	13	33	37	120
95th	9500	3.4	240	58	0.43	1.6	15000	50	68	160	29000	200	8300	340	0.96	2.3	63	0.75	22	44	42	200
Maximum	9700	3.5	300	60	0.45	1.8	17000	50	86	170	33000	210	8500	410	1.1	2.8	74	0.78	49	53	43	230
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	13	16	0	0	4	ns	0	14	7	ns	5	ns	ns	13	1	6	0	17	ns	0	2
Table 2 [5]	ns	0	16	0	0	0	ns	0	5	0	ns	1	ns	ns	0	0	0	0	1	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Of the seventeen samples collected from the green spaces along the western shore of Cobalt Lake, arsenic, cobalt, lead, and silver exceeded the *O. Reg. 153-04 Table 2 Generic Standard* in 94%, 29%, 6%, and 6% of the samples respectively. Arsenic concentrations were relatively low, ranging from 17 to 300 µg/g with a median concentration of 100 µg/g. Concentrations of the other metals were also low.

There was no spatial pattern of arsenic or metals along the western shore green space. Concentrations of arsenic and metals were similar along the length of the shore. There was a consistent pattern of concentration with depth. In general, concentrations of antimony, arsenic, cobalt, lead, nickel, and silver were lower at the surface than at depth. The median concentration of arsenic at 0 to 5 cm was 93 µg/g and 130 ug/g at 5 to 15 cm. Although the concentrations of arsenic were well above the Table 2 standards they were below levels that would be expected to cause damage to grass.

The results of the Pearson Correlations analysis showed significant correlations between arsenic and cobalt, manganese and nickel in the samples taken from the Cobalt Lake western shore green spaces (refer to Table B42.b and Figures B42.b.1 to B42.b.6). With the other elements there was a general trend of increasing concentration with increasing arsenic concentration however there was a lot of scatter to the data.

Table 4.4.3.3: Summary of Chemical Analysis of Soil Samples from the Cobalt Lake Green Spaces - Walking Trail

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	2300	0.2	13	8	0.1	0.2	130000	11	4	11	6600	9	20000	240	0.02	0.3	8	0.2	1	80	8	13
25th	2800	0.28	18	8	0.11	0.2	180000	12	5	12	7200	12	22000	260	0.025	0.7	9	0.2	1	97	10	16
50th	3200	0.35	22	9	0.12	0.2	210000	12	6	14	7400	14	23000	280	0.038	0.92	10	0.2	1	100	12	16
75th	3600	0.49	26	9	0.13	0.28	220000	13	7	16	7700	20	24000	280	0.062	1	10	0.2	1	100	13	19
Maximum	4200	0.7	28	10	0.15	0.29	230000	15	8	23	8600	31	26000	280	0.073	1.3	11	0.2	3	120	15	22
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	0	-	-	-	-	-	8	-	-	-	0	-	8	0	-	-	-	-	-	8	-	-
Table 1 [4]	ns	0	6	0	0	0	ns	0	0	0	ns	0	ns	ns	0	0	0	0	8	ns	0	0
Table 2 [5]	ns	0	4	0	0	0	ns	0	0	0	ns	0	ns	ns	0	0	0	0	0	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Concentrations of arsenic and metals along the walking path located at the north end of Cobalt Lake were very low. Arsenic barely exceeded the *O. Reg. 153-04 Table 2 Generic Standards* in four of the eight samples collected. Arsenic concentrations ranged from 13 to 28 µg/g.

The results of the Pearson Correlation analysis showed significant correlations between aluminum and chromium, iron, and vanadium in the samples collected from the Cobalt Lake

walking trail (refer to Table B42.c and Figures B42.c.1 to B42.c.6). The relationship between aluminum, chromium, iron, and vanadium were typical of uncontaminated material.

4.4.4 Cobalt Lake - Soccer Fields and Baseball Diamond

The land on which the Cobalt Lake soccer fields and baseball diamond are located was created from a peninsula of tailings deposited in the 1960s that was subsequently covered with rock and clean soil. The park initially included two baseball fields when it was originally opened in 1983 as can be seen in the air photo used in the sampling station map (Figure A37.1). The northern baseball field has since been converted into soccer fields.

Sampling at the Cobalt Lake Soccer Fields and Baseball Diamond was conducted on July 11th and 12th, 2006. Eighteen samples were collected from six sampling locations (refer to Maps A37.1, stations 748 to 757). Soil samples were collected with a corer at various depths from 5 x 5 m areas depending on the conditions at the sampling location. All samples were composites of a minimum of 10 cores.

The results of the chemical analysis of the samples collected from the Cobalt Lake Soccer Fields and Baseball Diamond are given in Appendix C, Tables C46.a and C46.b. Table C46.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C46.b. Results in Table C46.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.4.4 below.

Table 4.4.4: Summary of Chemical Analysis of Soil Samples from the Cobalt Lake - Soccer Fields and Baseball Diamond

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	4900	0.2	1	4	0.14	0.28	1900	22	6	8	9900	3	2600	150	0.007	0.3	14	0.2	1	6	23	20
5th	6000	0.2	2	4	0.16	0.28	2200	23	7	9	9900	4	2800	160	0.007	0.3	16	0.2	1	6	25	24
25th	8000	0.2	4	18	0.19	0.35	3000	25	8	11	12000	8	3600	170	0.016	0.33	17	0.2	1	13	28	30
50th	9700	0.2	16	24	0.22	0.43	4800	29	14	15	14000	11	4400	190	0.059	0.61	22	0.2	1	14	35	38
75th	15000	0.97	82	29	0.4	0.62	9400	60	22	30	21000	19	11000	380	0.2	1.2	36	0.2	4	31	48	60
95th	20000	3.1	240	64	0.76	1.1	15000	97	64	41	36000	71	16000	520	1.1	1.4	63	0.23	12	48	88	77
Maximum	21000	3.4	280	110	0.79	1.1	23000	100	67	46	37000	71	18000	550	1.1	1.7	63	0.38	13	50	91	83
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	3	-	1	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	4	9	0	0	2	ns	4	5	0	ns	0	ns	ns	3	0	3	0	18	ns	0	0
Table 2 [5]	ns	0	8	0	0	0	ns	0	3	0	ns	0	ns	ns	0	0	0	0	0	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic and cobalt were the only elements to exceed *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards. Eight of the eighteen samples exceeded the *Table 2 Standard* of 20 µg/g arsenic and three samples exceeded the cobalt standard of 40 µg/g Co. Of the few exceedances of the *Table 1 Background Standards*, antimony was exceeded in 22% of the samples, arsenic in 50%, cobalt in 9%, mercury in 17%, nickel 17%, and silver in 100% of the samples. Most of the silver exceedances were the result of the detection limits of the silver analysis (1.0 µg/g) being greater than the Table 1 standard of 0.47 µg/g and were not due to contamination by local mining activities. Arsenic concentrations ranged from 1 to 280 µg/g with a median concentration of 16 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver around Cobalt Lake are presented in Appendix A, Maps A37.2 to A37.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. Although the dot maps show an even distribution of arsenic and metals over the baseball and soccer fields, the concentrations of arsenic in the baseball field was higher than those found in the soccer fields. The higher concentrations in the baseball field were found below the surface. The median arsenic concentration at the surface for the whole area was 9 µg/g, at the intermediate depths, 42 µg/g, and at the deepest depths sampled, 100 µg/g. All but one of the Table 2 exceedances occurred in the baseball field samples taken below the surface. Although the arsenic concentrations at depth were elevated, they are significantly lower than the actual tailings underlying the playing fields, as seen by the concentrations found in the exposed tailings at stations 568 and 569.

The results of the Pearson Correlations analysis showed significant correlations between aluminum and chromium, iron and vanadium in the samples collected from the Cobalt Lake walking trail (refer to Table B43 and Figures B43.1 to B43.6). Although arsenic was significantly correlated with cobalt, lead, mercury, and silver, there were a large number of significant correlations between aluminum and other elements typical of clean background soil. These correlations reflect the clean nature of the topsoil, with a few marginally contaminated depth samples.

4.4.5 Cobalt Lake - Lion's Club Playground

The Lion's Club Playground is located on the southeast corner of the man-made peninsula along the eastern shore of Cobalt Lake between the tennis courts and Nipissing Hill. The playground is fenced off from the baseball diamond, tennis court and Cobalt Lake and contains two swing sets, a jungle gym, a slide and various other pieces of playground equipment. The area around the playground equipment was covered with beach sand.

Sampling at the Cobalt Lake Lions Club Playground was conducted on July 12th, 2006. Eight samples were collected from four sampling locations (refer to Maps A37.1, stations 754 to 757). Soil samples were collected with a corer at two depths, which varied depending on the location, from 5 x 5 m areas,. All samples were composites of a minimum of 10 cores. Samples were collected from around the picnic table, the large jungle gym, the base of the swings located in the southwest corner of the playground and just to the south of the swings in the southeast corner of the playground.

The results of the chemical analysis of the samples collected from the Cobalt Lake Lions Club Playground are given in Appendix C, Tables C46.a and C46.b. Table C46.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C46.b. Results in Table C46.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.4.5 below.

Table 4.4.5: Summary of Chemical Analysis of Soil Samples from the Cobalt Lake - Lions Playground

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	5000	0.2	1	12	0.14	0.22	2400	21	6	13	9600	3	3100	130	0.007	0.3	12	0.2	1	15	24	15
25th	5200	0.2	4	15	0.15	0.25	2700	24	7	15	10000	4	3400	130	0.007	0.3	14	0.2	1	16	25	20
50th	6800	0.2	18	18	0.18	0.36	2800	26	11	17	12000	6	3600	160	0.041	0.3	18	0.2	1	17	29	44
75th	8400	0.34	50	21	0.21	0.5	3000	28	15	19	14000	8	4200	190	0.07	0.42	20	0.2	2	18	34	60
Maximum	12000	1.9	140	29	0.31	0.84	3200	43	97	59	18000	37	5800	250	0.46	2	48	0.2	6	24	43	120
Stations [1]	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Samples [2]	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	1	4	0	0	0	ns	0	1	0	ns	0	ns	ns	1	0	1	0	8	ns	0	0
Table 2 [5]	ns	0	4	0	0	0	ns	0	1	0	ns	0	ns	ns	0	0	0	0	0	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic and cobalt were the only elements that exceeded *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards. Four of the eight samples exceeded the Table 2 standard of 20 µg/g arsenic and one sample exceeded the cobalt standard of 40 µg/g. Of the few exceedances of the *Table 1 Background Standards,* antimony was exceeded in 13% of the samples, arsenic in 50%, cobalt in 13%, mercury in 13%, nickel 13%, and silver in 100% of the samples. Most of the silver exceedances were the result of the detection limits of the silver analysis (1.0 µg/g) being greater than the Table 1 standard of 0.47 µg/g and were not due to contamination by local mining activities. Arsenic concentrations ranged from 1 to 400 µg/g, with a median concentration of 18 µg/g.

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, cobalt, nickel, and silver within the Cobalt Lake Lions Club Playground are presented in Appendix A, Maps A37.2 to A37.8 respectively. The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. The dot maps show a relatively even distribution within the playground. At the surface, the highest concentration was found around the picnic table which was just above the Table 2 standard. There was a distinct difference between the surface sample results and the depth sample results. Three of the four exceedances of the Table 2 standards were at depth. The median surface arsenic concentration was 9 µg/g and the median depth arsenic concentration was 74 µg/g. Although these arsenic concentrations were significantly lower than the arsenic concentrations of the tailings found below the soil layer, some of the tailings have been mixed into the soil at depth.

The results of the Pearson Correlations analysis show significant correlations between aluminum and most of the other metals such as chromium, iron, magnesium, manganese, and vanadium in the samples from the Cobalt Lake Lions Club Playground (refer to Table B44 and Figures B44.1 to B44.6). Although there was a general trend of increasing metal concentrations with increasing arsenic concentrations, the correlations were only moderate and were driven by the two results that were over 100 µg/g. The high degree of correlation between aluminum and the other elements is indicative of clean uncontaminated soil.

4.4.6 Other Cobalt Parks and Green Spaces

There are a number of small green spaces in Cobalt which are accessible to the public, many of which are associated with the historical tours of the town. Additional green spaces sampled as part of the Ministry's soil assessment program include the grassed area in front of the hockey arena (station 777), the grassed area around the Pig Town historical plaque (station 778), the grassed area around the original Cobalt Public School historical plaque (station 767), the Heritage Silver Trail (HST) Site 14 (stations 768 and 769), and the RV trailer park (stations 775 and 776) (refer to Maps A37.1).

Sampling at the other Cobalt Parks and Green Spaces was conducted on July 13th and 25th, 2006. Seventeen samples were collected from seven sampling locations. Soil samples were collected with either a corer or trowel from at least two depths where possible from 5 x 5 m areas. All samples were composites of a minimum of 10 cores or ten trowel samples. At the time of sampling, the surfaces of these green spaces were covered with healthy mown grass with the exception of the RV parking area.

The results of the chemical analysis of the samples collected from the other Parks and Green Space in Cobalt are given in Appendix C, Tables C48.a and C48.b. Table C48.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C48.b. Results in Table C48.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.4.6.

As would be expected, given the distances between the various green spaces sampled, there was a wide range in the concentrations of arsenic and metals between the sites. Although the concentrations of arsenic and metals in the green spaces were relatively low, arsenic, cobalt, copper, lead, and silver exceeded *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in 53%, 24%, 6%, 18%, and 24% of the samples respectively. Six of the arsenic exceedances occurred at the hockey arena and historical Pig Town sites. Both of these locations are adjacent to, and down hill from, the Coniagas Mill and were most likely contaminated by tailings from the mill. The other three arsenic exceedances, two at Heritage Silver Trail Site 14 and one at the original Public School, were found at the lower of the two depths sampled, with the surface samples falling below the Table 2 standards. Arsenic concentrations ranged from 3 to 470 µg/g, with a median concentration of 32 µg/g. Lead concentrations were also high at the Pig Town historical site ranging from 390 to 700 µg/g.

Table 4.4.6: Summary of Chemical Analysis of Soil Samples from the Other Parks and Greenspaces

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	4200	0.2	3	24	0.17	0.25	2900	21	5	11	8000	6	2800	190	0.0077	0.3	14	0.2	1	16	17	28
5th	4800	0.2	3	24	0.18	0.25	4800	23	6	12	9000	9	3000	190	0.018	0.3	15	0.2	1	19	21	30
25th	7300	0.2	13	29	0.23	0.36	6300	29	10	16	12000	23	4700	210	0.062	0.3	20	0.2	1	22	29	46
50th	9000	1	32	36	0.28	0.46	8300	39	18	36	14000	38	5000	260	0.15	1.2	28	0.24	2	24	35	77
75th	12000	2.2	120	71	0.49	0.6	12000	47	32	60	20000	98	6900	330	0.48	2.1	45	0.32	16	44	43	130
95th	14000	8.2	410	190	1	1.5	13000	56	120	180	30000	580	7800	670	3.4	2.6	100	1.2	58	53	50	430
Maximum	15000	8.8	470	210	1.2	1.8	15000	60	130	240	32000	700	8100	800	3.6	2.6	110	1.2	72	60	59	490
Stations [1]	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Samples [2]	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	7	10	0	0	4	ns	0	6	4	ns	4	ns	ns	6	2	5	0	17	ns	0	4
Table 2 [5]	ns	0	9	0	0	0	ns	0	4	1	ns	3	ns	ns	0	0	0	0	4	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

The results of the Pearson Correlations analysis showed significant correlations between arsenic and antimony, cadmium, cobalt, copper, iron, lead, mercury, nickel, silver, and zinc in the samples collected from the other Cobalt green spaces (refer to Table B45 and Figures B45.1 to B45.6). For many of the elements these correlations were driven by the six high samples found

at the hockey arena and the historical Pig Town site. The correlations of arsenic with cobalt and nickel were however strong even at the lower concentrations, indicating that all of these green spaces have been contaminated to at least a small degree by mining activities in the town.

4.5 Residential Properties

Many residences in the Cobalt-Coleman Mining Camp were built in the middle all of the historical mining and milling activity in the area. Often homes were built immediately adjacent to these activities. Instead of sampling all of the residential properties in the camp or a random sampling of these properties the decision was made to sample only those residential properties directly adjacent to some of the major mill sites or tailings areas. The two main areas sampled included properties established on or adjacent to the Buffalo Mills and Tailings and properties backing onto the Nipissing Low Grade Tailings. Other properties near the Cobalt Reduction Mill, the Mile 104 Mill, and the Hudson Bay Tailings were also sampled.

4.5.1 Residential Properties Adjacent to the Buffalo Mills and Tailings

Tailings from the Buffalo Mills were originally located in a narrow valley between the two mills, nd extending to Trailer Park Road to the northeast, across Prospect Avenue, and along the east side of Dunning Drive through the area currently occupied by the Cobalt-Coleman Public School. The tailings were covered over with approximately six inches of gravel, sand mixed with stones and rocks similar to glacial till, and approximately six inches of topsoil (Anderson, 1993). There are approximately twenty-four trailer homes currently located on Trailer Park Road.

Sampling of select residential properties adjacent to the Buffalo Mills and Tailings was conducted on May 16th, 2007. Forty-seven samples were collected from twelve sampling locations on nine properties (stations 803 to 814). Soil samples were collected with a corer at multiple depths up to 50 cm from 5 x 5 m areas. All samples were composites of a minimum of 10 cores. Cores were taken to the maximum depth possible for a hand soil corer to determine the thickness of the soil and gravel layer covering the tailings. In some instances the gravel layer could not be penetrated by the hand corer.

The results of the chemical analysis of the samples collected from select residential properties adjacent to the Buffalo Mills and Tailings are given in Appendix C, Tables C49.a and C49.b. Table C49.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and paramete rs not captured under *Ont. Reg. 153-04* are given in Table C49.b. Results in Table C49.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.5.1 below.

Table 4.5.1: Summary of Chemical Analysis of Soil Samples for Residential Properties Adjacent to the Buffalo Mill and Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	6800	1	4	6	0.17	0.2	2300	21	7	10	10000	9	2500	150	0.037	0.3	15	0.2	1	6	23	27
5th	8200	1	7	7	0.22	0.28	3000	25	8	13	10000	11	3000	200	0.062	0.3	17	0.2	1	7	26	39
25th	10000	1	22	22	0.26	0.37	4500	28	12	22	12000	21	3800	220	0.16	0.3	21	0.2	3	15	31	58
50th	12000	2.6	79	30	0.36	0.54	6000	39	31	41	16000	45	4900	280	0.63	0.35	32	0.2	11	17	36	77
75th	16000	10	360	36	0.56	0.85	9700	60	94	150	25000	100	10000	430	3.4	0.59	90	0.3	58	21	56	150
95th	20000	33	1300	69	0.83	1.9	13000	91	260	400	33000	360	15000	540	88	1.1	160	0.83	190	34	88	470
Maximum	20000	44	2700	110	0.89	2.5	34000	95	550	710	35000	460	15000	1200	350	1.9	250	1.4	490	41	93	580
Stations [1]	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Samples [2]	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	2	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	35	36	0	0	8	ns	9	29	20	ns	10	ns	ns	31	0	22	0	47	ns	1	10
Table 2 [5]	ns	9	35	0	0	0	ns	0	21	7	ns	8	ns	ns	8	0	4	0	20	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

A large number of samples collected from the nine residential properties exceeded both the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards. Antimony, arsenic, cobalt, copper, lead, mercury, nickel, and zinc exceeded both standards in 19%, 74%, 45%, 15%, 17%, 17%, 9%, and 45% of all the samples respectively. In the surface samples antimony, arsenic, cobalt, copper, lead, mercury, nickel and zinc exceeded both standards in 0%, 55%, 9%, 0%, 0%, 0%, 0% and 9% of all the samples respectively. This was significantly less than the the samples taken at depth. Arsenic concentrations ranged from 4 to 2,700 µg/g with a median concentration of 79 µg/g. Arsenic concentrations in the surface samples ranged from 6 to 1,300 µg/g with a median concentration of 26 µg/g.

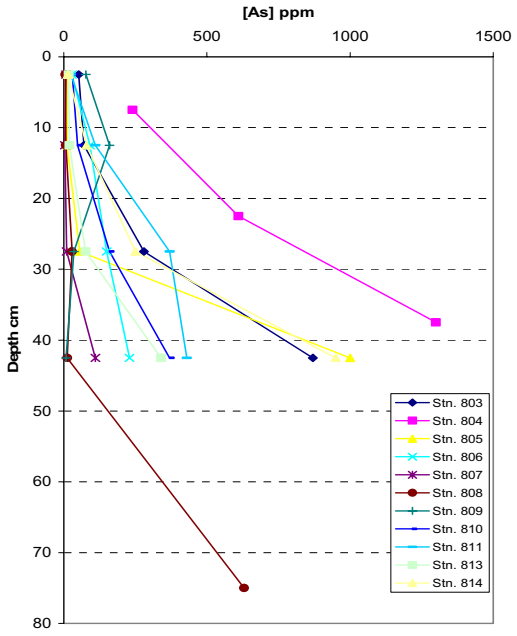


Figure 4.5.1: As profiles.

Concentration dot maps were not produced for any of the residential properties. Generally, the concentration of arsenic and other metals was evenly spread over the area, with the highest concentrations being found immediately adjacent to the two mills. There was a distinct depth profile for arsenic and the other metals at all but one sample site. Arsenic concentrations increased with depth with the highest concentrations being found at the deepest depths (refer to Figure 4.5.1). The highest concentrations at both surface and depth were found in a vegetable garden containing highly organic soil however it appears that tilling of the soil may have resulted in tailings being incorporated into the organic soil.

The results of the Pearson Correlation analysis showed significant correlations between arsenic and antimony, cadmium, cobalt, lead, mercury, nickel, and zinc in the samples collected from the residential properties adjacent to the Buffalo Mills (refer to Table B46a and Figures B46a.1 to B46a.6). Aluminum was also significantly correlated with chromium, iron, vanadium, and to a lesser extent with magnesium and manganese. These correlations suggest a mix of clean top soil combined with tailings originating from a single source.

There is clear evidence that significantly elevated concentrations of arsenic are found at depths

below 30 cm in the residential community built on the old Buffalo Tailings. Any digging on these properties below 30 cm risks exposure to these high arsenic concentration soils.

4.5.2 Residential Properties Adjacent to the Nipissing Low Grade Tailings

There are a number of residential properties located on the east side of Nipissing Road in Coleman Township that back directly on to the Nipissing Low Grade Tailings. In most cases there is no distinct demarcation between the residential property boundary and the beginning of the tailings.

Sampling of select residential properties adjacent to the Nipissing Low Grade Tailings was conducted on May 16th and 17th, 2007. Twenty-four samples were collected from six sampling locations on five properties (stations 815 to 820). Soil samples were collected with a corer at 0 to 5 cm, 5 to 20 cm, 20 to 35 cm, and 35 to 50 cm depths from 5 x 5 m areas. All samples were composites of a minimum of 10 cores. Sampling was restricted to the backyard of each property as these were the areas expected to be most impacted by the tailings.

The results of the chemical analysis of the samples collected from the residential properties adjacent to the Nipissing Low Grade Tailings are given in Appendix C, Tables C48.a and C48.b. Table C48.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C48.b. Results in Table C49.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.5.2 below.

Arsenic was the only element to exceed both of the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty-four of the samples collected from the residential properties adjacent to the Nipissing Low Grade tailings. Antimony, cobalt, copper, lead, mercury, nickel, silver, and zinc exceeded the *Table 2 Generic Standard* in 29%, 46%, 29%, 38%, 25%, 29%, 38%, and 4% of the samples respectively. Arsenic concentrations ranged from 46 to 3,700 µg/g with a median concentration of 130 µg/g.

Table 4.5.2: Summary of Chemical Analysis of Soil Samples for Residential Properties Adjacent to the Nippissing Low Grade Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	9000	1	46	15	0.23	0.35	6700	26	12	19	12000	17	4500	230	0.31	0.3	23	0.2	3	13	25	33
5th	9200	1.4	61	22	0.26	0.37	7400	26	14	23	12000	23	4900	280	0.34	0.3	27	0.2	3	15	26	53
25th	12000	2.5	83	43	0.38	0.44	14000	35	25	27	16000	50	9200	440	1.1	0.42	40	0.31	6	22	29	110
50th	14000	4.9	130	60	0.47	0.76	17000	42	39	40	20000	100	11000	620	2.3	0.6	55	0.7	10	24	32	210
75th	17000	32	770	94	0.6	0.98	22000	58	200	240	25000	260	15000	670	7.6	0.9	270	1	31	26	51	370
95th	23000	57	2600	140	0.77	1.5	24000	90	580	400	35000	510	18000	720	13	2	600	1.2	110	39	92	530
Maximum	24000	110	3700	240	0.78	2.3	42000	92	850	410	36000	760	21000	820	23	2.1	850	1.4	120	52	95	730
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	3	-	3	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	23	24	1	0	5	ns	5	19	7	ns	11	ns	ns	24	0	14	0	24	ns	2	13
Table 2 [5]	ns	7	24	0	0	0	ns	0	11	7	ns	9	ns	ns	6	0	7	0	9	ns	0	1

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

The spatial distributions of arsenic, antimony, cobalt, lead, mercury, nickel, and silver are presented in Appendix A (Maps A37.2 to A37.8 respectively). The concentration of each sample at each sampling location is represented by a dot; the larger and darker the dot the higher the concentration. It can clearly be seen that those sampling locations closest to the tailings had the highest concentration of arsenic and other metals. These concentrations dropped off rapidly with increasing distance from the tailings. At the locations reporting the highest concentrations of arsenic and metals, tailings were actually observed just below the surface and concentrations increased with increasing depth. The remaining sampling locations still showed a profile of increasing arsenic concentration with increasing depth however the increases were significantly lower (refer to Figure 4.5.2)

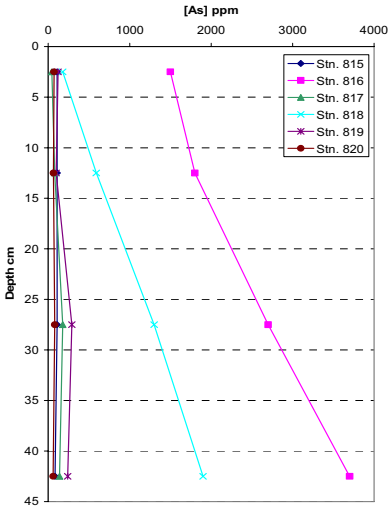


Figure 4.5.2: As Profiles.

The results of the Pearson Correlation analysis showed significant correlations between arsenic and antimony, chromium, cobalt, copper, iron, molybdenum, nickel, and silver in the samples collected from the residential properties adjacent to the Nipissing Low Grade tailings (refer to Table B46b and Figures B46b.1 to B46b.6). As with the residential properties adjacent to the Buffalo Mills, there were a large number of significant correlations with aluminum and other metals. These two sets of correlations reflect the relatively clean top soil mixed with tailings at these sites.

Unlike the residential properties adjacent to the Buffalo Mills, the topsoil in the backyards adjacent to the Nipissing Low Grade tailings has been contaminated to a slightly greater degree. This is possibly the result of tailings dust blowing onto these properties prior to the tailings being capped with clay soil.

4.5.3 Residential Properties Adjacent to Other Mills and Tailings

Residential properties were also sampled in the vicinity of three other mill and tailing locations including the Cobalt Reduction Mill, the Mile 104 Mill, and the Hudson Bay tailings. Sampling of these residential properties was conducted on May 17th and 18th, 2007. Twenty samples were collected from six sampling locations at four residential properties (stations 822 to 826). Soil samples were collected with a corer at 0 to 5 cm, 5 to 20 cm, 20 to 35 cm, and 35 to 50 cm depths from 5 x 5 m areas. All samples were composites of a minimum of 10 cores. The samples at station 826 were taken at a depth of 0 to 5 cm using a trowel.

The results of the chemical analysis of the samples collected from select residential properties adjacent to other mills and tailings are given in Appendix C, Tables C48.a and C48.b. Table C49.a includes those elements for which there are *Ont. Reg. 153-04 Soil Standards*. Results exceeding the *Ont. Reg. 153-04 Soil Standards Table 1 Background Standards* have been highlighted in bold font and results exceeding the *Ont. Reg. 153-04 Soil Standards Table 2 Generic Standards* have been highlighted in bold and underlined. The results for the elements and parameters not captured under *Ont. Reg. 153-04* are given in Table C48.b. Results in Table C48.b exceeding the Ontario Typical Range (OTR_{98}) guidelines have been highlighted in bold font.

Summary statistics including the number of stations sampled, the number of samples collected, a

summary of the chemical analysis, and the number of samples that exceeded the *Ont. Reg. 153-04 Soil Standards* or the OTR_{98} guidelines are given in Table 4.5.3 below.

Table 4.5.3: Summary of Chemical Analysis of Soil Samples for Residential Properties Adjacent to other Mills and Tailings

Percentile	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Minimum	8800	1.6	28	14	0.25	0.25	3700	30	13	33	11000	25	3700	220	0.13	0.3	23	1	2	9	23	84
5th	9200	1.8	37	33	0.29	0.34	4800	30	16	42	12000	55	4500	260	0.15	0.31	26	1	4	14	25	88
25th	11000	2.6	81	44	0.34	0.55	6800	38	29	90	16000	110	5400	290	0.36	0.68	39	1	9	22	34	130
50th	14000	5.9	250	62	0.44	0.78	8200	44	72	160	18000	160	6300	360	0.66	0.98	66	1	22	24	40	180
75th	16000	12	550	99	0.69	1.1	13000	56	170	290	24000	310	9100	500	1.2	1.3	100	1	42	27	44	340
95th	19000	22	2200	220	0.76	1.7	19000	67	930	750	28000	460	14000	670	2.4	2.9	260	1.2	110	36	66	580
Maximum	21000	22	4600	260	0.84	1.9	25000	80	1500	770	30000	520	15000	740	4.2	3	450	1.2	320	43	78	590
Stations [1]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Samples [2]	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
OTR_{98} [3]	0	-	-	-	-	-	0	-	-	-	0	-	0	0	-	-	-	-	-	0	-	-
Table 1 [4]	ns	20	20	2	0	6	ns	1	18	15	ns	14	ns	ns	17	2	14	0	20	ns	0	12
Table 2 [5]	ns	5	20	0	0	0	ns	0	14	7	ns	7	ns	ns	0	0	3	0	10	ns	0	0

[1] - number of stations sampled at this location
[2] - number of samples analyzed for this element from this location
[3] - number of samples exceeding the OTR_{98} Old Urban Parkland Guideline
[4] - number of samples exceeding the *Reg. 153/04 Table 1 Background Standard*
[5] - number of samples exceeding the *Reg. 153/04 Table 2 Generic Cleanup Standard*
ns - no *Reg. 153/04 Standard* for this element
- all results are expressed in µg/g dry weight

Arsenic was the only element to exceed both the *O. Reg. 153-04 Table 1 Background* and *Table 2 Generic* soil standards in all twenty of the samples collected from the residential properties adjacent to the other mill and tailing sites. Antimony, cobalt, copper, lead, nickel, and silver exceeded the *Table 2 Generic Standard* in 25%, 70%, 35%, 35%, and 15% of the samples respectively. Arsenic concentrations ranged from 286 to 4,600 µg/g with a median concentration of 250 µg/g.

All of the residential properties showed higher concentrations with increasing depth in the soil to some degree (refer to Figure 4.5.3). The range was very small (site 825 near the Hudson Bay tailings) to very large (site 826 near the Mile 104 Mill). Site 824 was a vegetable garden in which organic soil had been brought in. High concentrations were found at all depths at this site suggesting that tailings may have been incorporated into the organic soil during tilling.

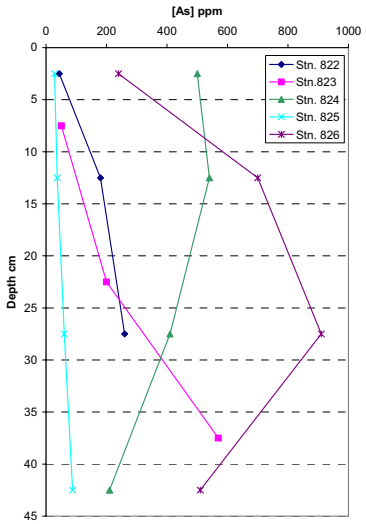


Figure 4.5.3: As Profiles

All of the residential properties adjacent to the mining sites had some degree of arsenic contamination in the soil ranging from very minor at site 825 to quite significant at site 826.

5. Summary

Over one hundred years of mining and milling activity in the Cobalt-Coleman Mining Camp has resulted in significant impacts to the local environment. Most of these impacts occurred between 1906 and the 1930s at a time when there was little or no concern for the environment and there were no government regulations regarding tailings management and site decommissioning or closure.

The Ministry's soil assessment program is the first comprehensive inventory of the impacts of past mining activities on the terrestrial environment in the Cobalt area although a number of studies have been previously conducted by various federal and provincial government agencies, universities and consultants. Almost 2,000 soil samples were collected from 640 sampling locations in the Cobalt-Coleman Mining Camp. Twenty mill sites, fourteen tailings areas, and fifteen mine sites were sampled as part of the investigation. A number of sites however were not sampled as part of the Ministry's program including the Penn-Canadian Mill, the Canadaska tailings, the Fernad Chamberland tailings, and the Far Creek tailings. In addition, only a small fraction of the total number of mine sites and waste rock dumps located in the area were sampled as part of this investigation.

Silver was the main focus of the mining activities in the Cobalt-Coleman area although nickel, cobalt, and even arsenic were also recovered on a commercial basis from the ore that was mined. There were also a number of other elements incorporated into the local mineral deposits, many of which have ended up in the tailings and mill wastes.

Soil samples collected by the Ministry were analyzed for antimony, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, vanadium and zinc.

Extensive areas of contamination were found within the mines, mills, and tailings areas that comprise the Cobalt-Coleman Mining Camp. Many sites reported elevated concentrations of various metals above the province's background and effects-based soil standards (Ontario Regulation 153) (refer to Table 5.1). Elevated concentrations of metals were also found to a lesser extent in some of the green spaces and residential properties sampled as part of the Ministry's soil assessment program.

Table 5.1: Summary of Chemical Analysis of Soil Samples from all 2003 to 2007 Sampling

	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Mo	Ni	Se	Ag	V	Zn
Minimum	0.2	1	4	0.09	0.2	2	1.3	3	6.7	0.007	0.1	4.2	0.2	0.6	7	5
5th	1	7	6	0.20	0.2	20	17	32	13	0.057	0.3	31	0.2	5	21	29
25th	5	1,000	12	0.60	0.5	55	230	130	100	1.6	0.8	120	0.2	30	48	140
50th	40	2,300	32	0.80	1.7	85	640	380	190	11	1.6	330	0.2	64	77	300
75th	170	7,900	70	0.97	5.4	100	2,600	1,000	460	50	8.6	1,700	0.24	190	100	770
95th	590	46,000	150	1.20	12.0	140	16,000	2,800	1,800	280	110	8,300	0.6	850	140	2,000
Maximum	3,700	160,000	1,100	5.50	31.0	1,100	54,000	24,000	4,400	2,100	1,100	53,000	25	19,000	230	23,000
No. Stations	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640
No. Samples	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947	1,947
Reg. 153/04 Table 1	92%	95%	2%	6%	52%	65%	93%	82%	71%	90%	37%	90%	2%	100%	51%	66%
Reg. 153/04 Table 2	51%	94%	0.2%	6%	3%	0.2%	90%	62%	55%	31%	5%	10%	0.3%	75%	0.2%	29%

- Results for 2 mm sieve size only

The major contaminants found (in descending order of the number of samples exceeding the *Table 2 Generic Effects-Based soil standards*) include arsenic, cobalt, silver, copper, lead, antimony, mercury, zinc and nickel. It should be noted that while mercury is only a minor constituent of the ore in the Cobalt area mineral deposits, the high concentrations of mercury found at some locations is the result of the use of mercury in the refining process for silver in the early years of the camp. Barium, beryllium, cadmium, chromium, molybdenum, selenium, and

vanadium exceeded the *Table 2 Generic Effects-Based soil standards* on rare occasion and are not considered significant contaminants in the Cobalt-Coleman Mining Camp.

Concentrations of antimony, cobalt, copper, lead, mercury, nickel, silver, and zinc generally increased with increasing concentrations of arsenic, however, at some locations, there were weak correlations between arsenic and some of these elements. It can not, therefore, be assumed that these metals are correlated and that the cleaning up of one metal will clean up all occurrences of other metals.

5.1 Arsenic

Arsenic contamination in the Cobalt-Coleman Mining Camp is a major concern from both a human health and ecological standpoint. Arsenic was a major component of the ores in the Cobalt area and occurred in very high concentrations. Unlike the majority of other mining areas in northern Ontario, arsenic in the ores from Cobalt is found in a more available form and readily leaches from tailings. The current *O. Reg. 153-04 Table 2 Generic* soil standard for arsenic is 20 µg/g. The arsenic standard is based on the ecological effects of arsenic on vegetation. Historically arsenic was used as a herbicide and arsenic from Cobalt was used to make herbicides.

The fifty-eight discreet locations sampled in the Cobalt-Coleman Mining Camp have been ranked based on the median arsenic concentration and are presented in Figure 5.1.1 below. The median concentrations and the 25th and 75th percentile values (blue bars) are also presented.

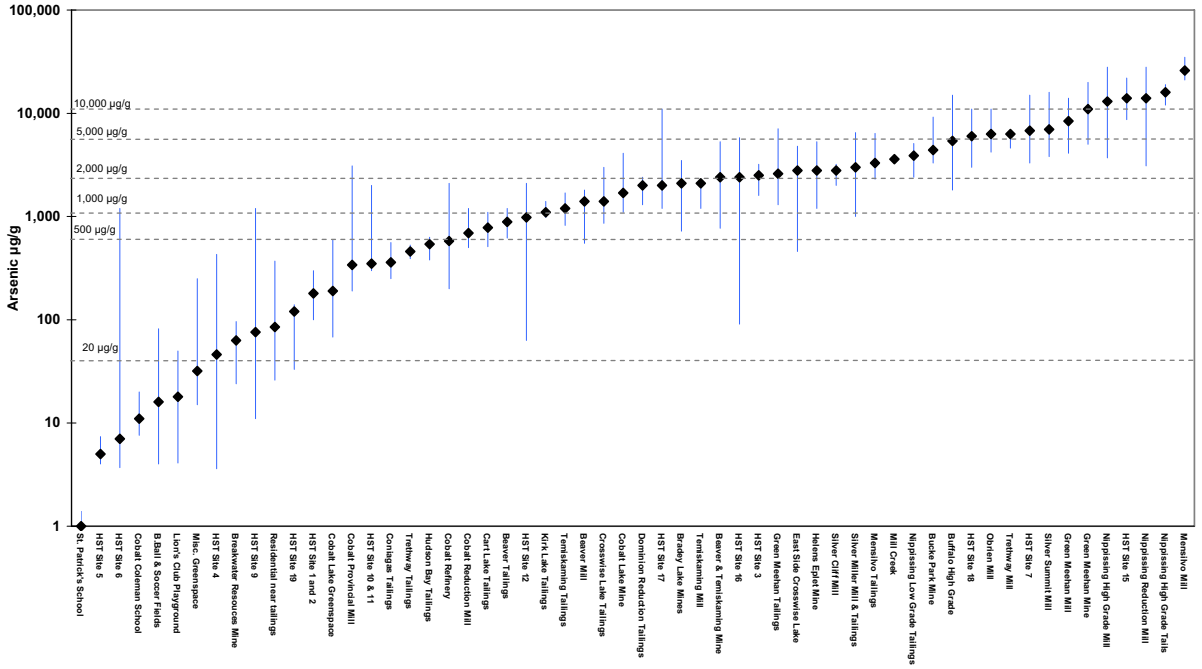


Figure 5.1.1: 58 locations ranked by median arsenic concentrations (µg/g), with 25th and 75th percentile bars.

Only six of the fifty-eight sampling locations had median arsenic concentrations below the *Table 2 Generic Standard* of 20 µg/g. Eleven sampling locations had median arsenic concentrations below 100 µg/g which included all of the schools, parks, green spaces and residential areas sampled as well as some of the Heritage Silver Trail sites. Conversely, thirty-four of the fifty-eight sampling locations had median arsenic concentrations over 1000 µg/g.

As expected, samples collected from mining locations had the highest concentrations of arsenic. Mining locations were categorized into mines, mills and tailings sites and then ranked according to median arsenic concentrations (refer to Figures 5.1.2 to 5.1.4).

Fifteen mine sites were sampled in the Cobalt-Coleman Mining Camp. Arsenic was found in waste rock fine material, waste rock dumps, and/or spread throughout the mine sites. Two distinct populations exist in the sampling data. The first population consists of the seven mine sites that had median arsenic concentrations below 200 µg/g. The second group consists of the mine sites that had median arsenic concentration ranging between 2,100 to 11,000 µg/g. The highest concentrations were found at the Crown Reserve and Green Meehan Mines. Often, but not always, the high concentration of arsenic in waste rock fine material was associated with rust-stained waste rock.

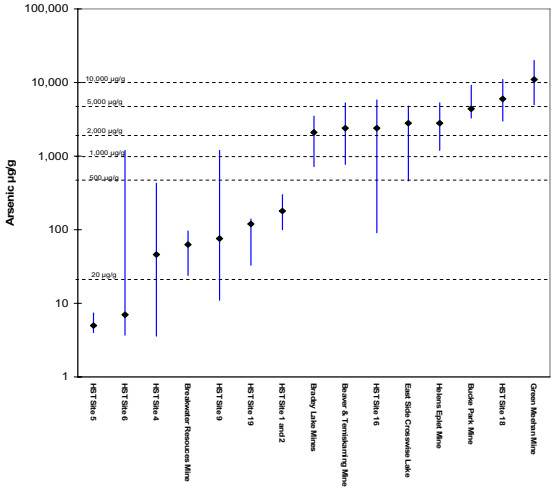


Figure 5.1.2: Mines, median [As].

Twenty mill sites were sampled in the Cobalt-Coleman Mining Camp. Three had median arsenic concentrations below 700 µg/g, thirteen had median concentrations between 1,400 and 8,400 µg/g, and four had median concentrations between 14,000 and 26,000 µg/g. The four highest median concentrations were found at the Nipissing High Grade Mill, the Mile 104 Mill, the Nipissing Reduction Mill loading area and the Mensilvo Mill respectively.

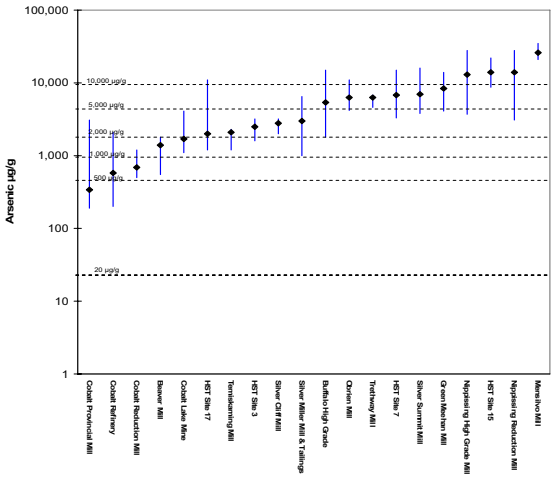


Figure 5.1.3: Mills, median [As].

It should be noted however that the median concentration of a mill site does not always represent the degree of arsenic contamination for the site as a whole. In cases like the Trethway Mill, which wa s largely cleaned up when it was decommissioned, there were only a couple of small areas with enough material to sample and these happened to have high arsenic values.

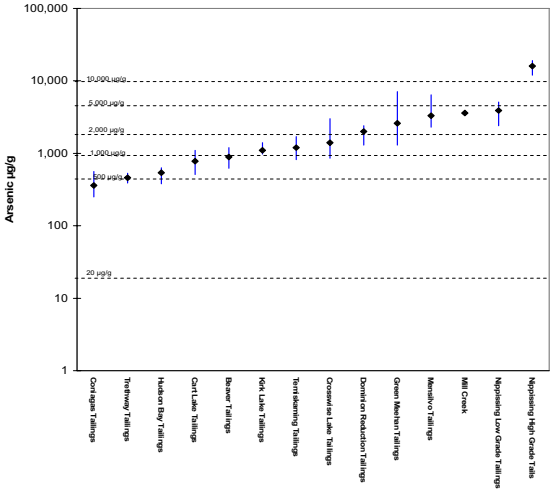


Figure 5.1.4: Tailings, median [As].

Fourteen tailings sites were sampled in the Cobalt-Coleman Mining Camp. The tailings can generally be broken down into two main types. The first type of tailings was the coarser grained tailings produced by gravity mills. These tailings of arsenic. The six lowest median tailings generally had lower median concentrations, which ranged from 360 to 1,200 µg/g, were all coarse grained tailings. The

second type of tailings were the much finer grained tailings produced by flotation mills.

All but one of the five highest median concentrations were found in fine grained tailings. The highest median arsenic concentrations were reported at the Green Meehan, Mensilvo, Mill Creek, Nipissing Low Grade, and Nipissing High Grade tailings respectively. The arsenic concentrations found in the tailings never approached the concentrations found at the mill sites but were generally higher than those found at the mine sites. The range of arsenic concentrations at the tailings site was usually quite small as the tailings were generally from the same mill. Some tailings sites, like the Crosswise Lake tailings, had more variability in arsenic concentrations due to the number of mills that deposited their tailings the same location.

5.2 Antimony

Antimony contamination was site specific, unlike arsenic and cobalt, which was found at all locations in the Cobalt-Coleman Mining Camp and whose concentrations were usually correlated. The concentration of antimony found naturally occurring in soil is very low. The current *O. Reg. 153-04 Table 1 Background* soil standard for antimony is 1.0 µg/g. At industrial sites, such as secondary lead smelters where antimony emissions are a concern, antimony concentrations seldom exceed the *Table 2 Generic Standard*. The current *O. Reg. 153-04 Table 2 Generic* soil standard for antimony is 13 µg/g. The antimony standard is based on the ecological effects of antimony on vegetation.

The fifty-eight discreet locations sampled in the Cobalt-Coleman Mining Camp have been ranked based on the median antimony concentration and are presented in Figure 5.2.1 below. The median concentration and the 25th and 75th percentile values (blue bars) are also presented.

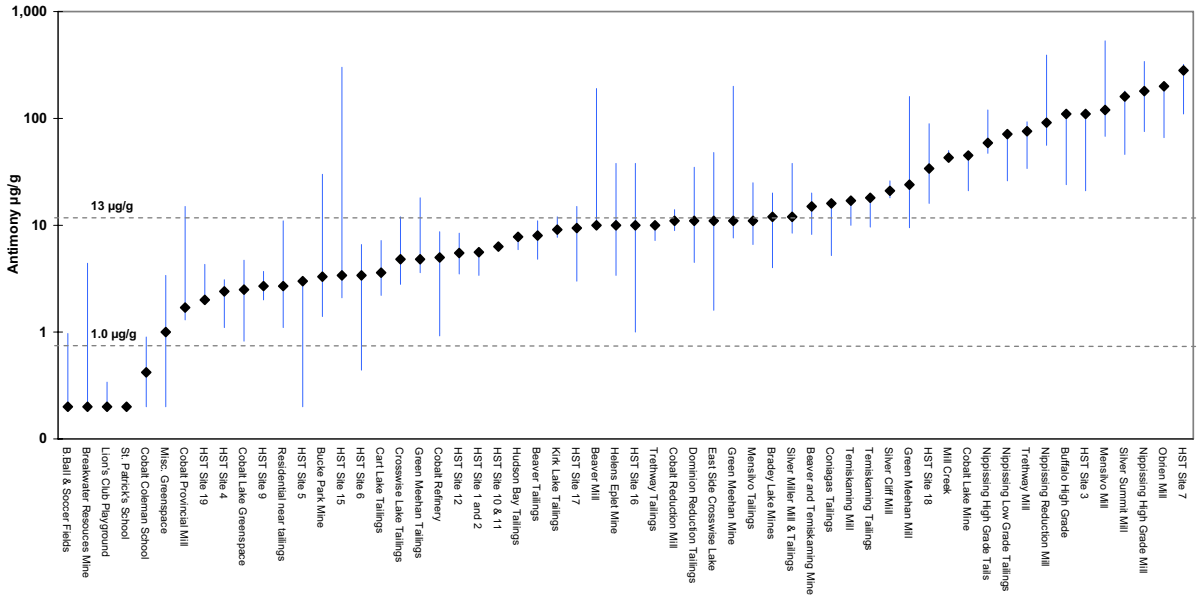


Figure 5.2.1: 58 locations ranked by median antimony concentrations (µg/g), with 25th and 75th percentile bars.

Only six of the fifty-eight sampling locations had median antimony concentrations below the *Table 1 Background Standard* of 1.0 µg/g. Thirty-two of the sampling locations had median antimony concentrations above the Table 1 Background standards but below the *Table 2 Generic Standard* for antimony of 13 µg/g. All of the schools, parks, and green spaces had median antimony concentrations below the *Table 2 Generic Standard*. Of the twenty sampling locations with median antimony concentrations above the *Table 2 Generic Standard*, eleven were above 65 µg/g (five time the Table 2 standard). The locations with the highest antimony concentrations

were found at the Nipissing High and Low Grade Mills and the O'Brien Mill.

As expected, samples taken from the mining locations had the highest concentrations of antimony. The mining locations have been categorized into mines, mills, and tailings sites and then ranked according to median arsenic concentrations (refer to Figures 5.2.2 to 5.2.4).

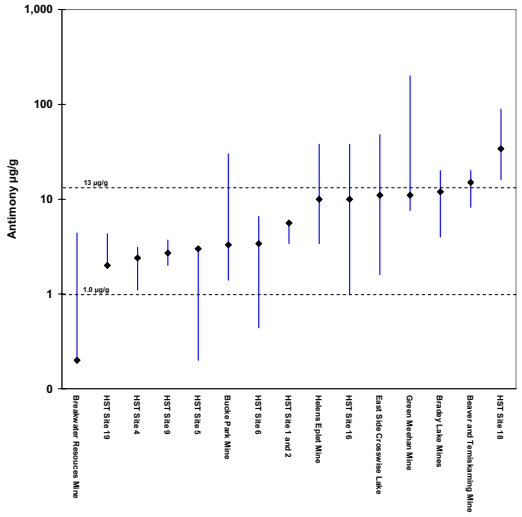


Figure 5.2.2: Mines, median [Sb]

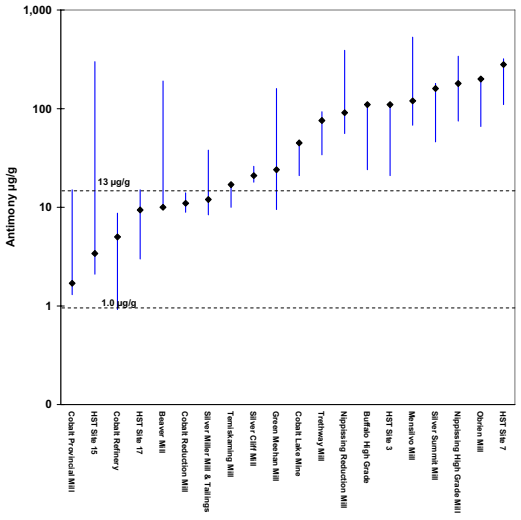


Figure 5.2.3: Mills, median [Sb].

Of the fifteen mine sites sampled as part of the Ministry's investigation, twelve had median antimony concentrations that fell between the *Table 1 Background Standard* and the *Table 2 Generic Standard* for antimony. Only two sites had median antimony concentrations that were just above the Table 2 standard. Sampling locations in the mills had the highest antimony concentrations in the mining camp. Thirteen of the twenty mill sites had median antimony concentrations above the *Table 2 Generic Standard* with seven of these having median concentrations above 100 µg/g. The highest antimony concentrations of 5,000 µg/g were found at the Nipissing High Grade Mill and Tailings.

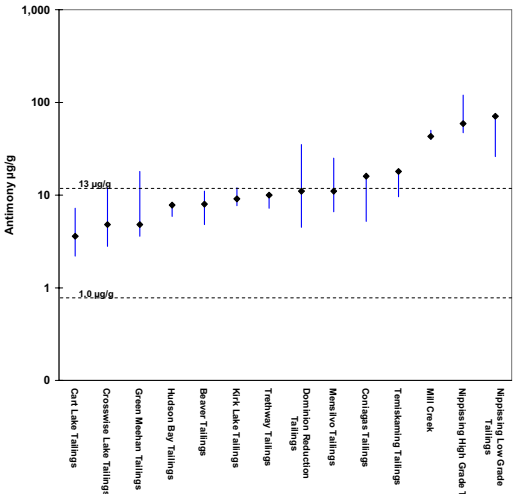


Figure 5.2.4: Tailings, median [Sb]

5.3 Lead

Lead in the Cobalt-Coleman Mining Camp is similar to antimony in that lead contamination is more site-specific than arsenic contamination. The concentration of lead found naturally occurring in soil is relatively low. The historical use of lead in gasoline, paints and other products however, has resulted in background concentrations in cities and towns that are above natural levels. The current *O. Reg. 153-04 Table 1 Background* soil standard for lead is 120 µg/g. The current *O. Reg. 153-04 Table 2 Generic* soil standard for lead is 200 µg/g. The lead standard is based on human health effects.

The fifty-eight discreet locations sampled in the Cobalt-Coleman Mining Camp have been ranked based on the median lead concentration and are presented in Figure 5.3.1 below. The median concentration and the 25th and 75th percentile values (blue bars) are also presented.

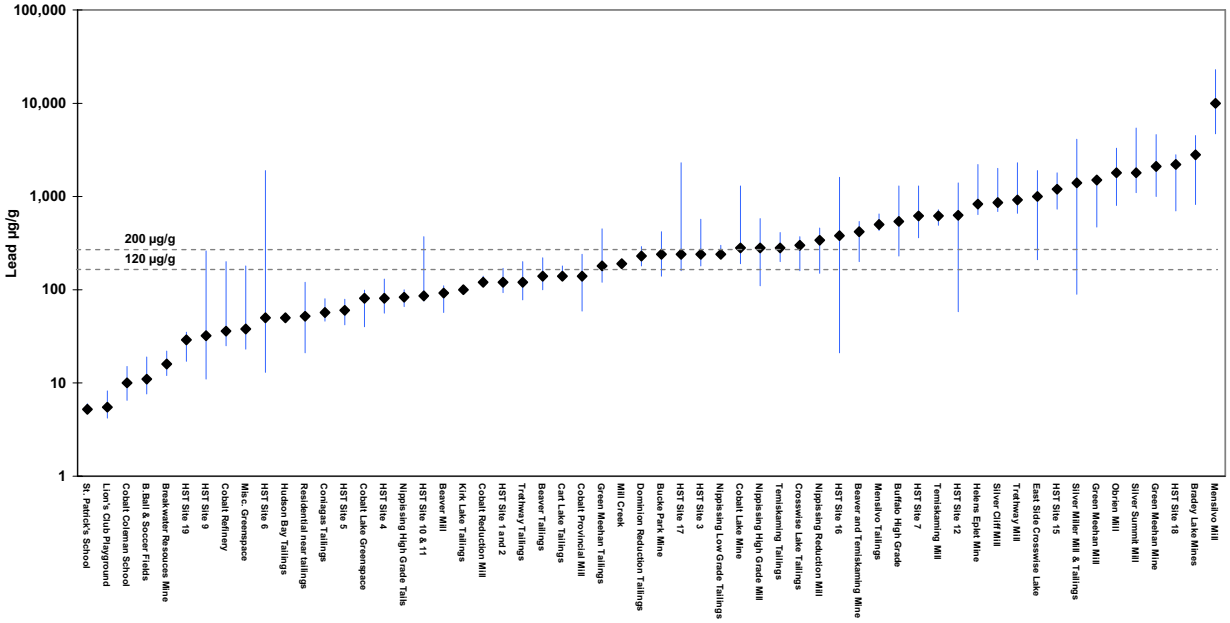


Figure 5.3.1: 58 locations ranked by median lead concentrations (µg/g), with 25th and 75th percentile bars.

Twenty-three of the fifty-eight sampling locations had median lead concentrations below the *Table 1 Background Standard* of 120 µg/g. This included all of the schools, parks and green space groupings. There were only five locations with median lead concentrations between the *Table 1 Background* and *Table 2 Generic Standards*. The remaining thirty locations had median concentrations greater than the 200 µg/g Pb *Table 2 Generic Standard*. Ten locations had median lead concentrations over 1,000 µg/g. All of these locations were either mill or mine sites.

As expected, the mining locations had the highest concentrations of lead. The mining locations have been categorized into mines, mills and tailings sites and ranked according tomedian lead concentrations (refer to Figures 5.3.2 to 5.3.4).

The fifteen mine sites had a wide range of median lead concentrations. Seven of the mine sites had median lead concentrations below the *Table 2 Generic Standard* and eight were above the *Table 2 Generic Standard.* There were four mine sites with median lead concentrations over 1,000 µg/g. In the majority of the mine sites reporting high lead concentrations, lead as well as arsenic was found in waste rock fine material that was distinctly rust coloured compared to the typical grey waste rock. There was a wide range of lead concentrations found at the mine sites

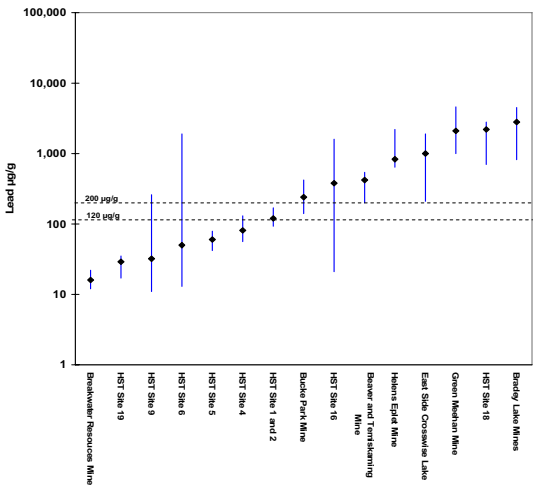


Figure 5.3.3: Mines, median [Pb].

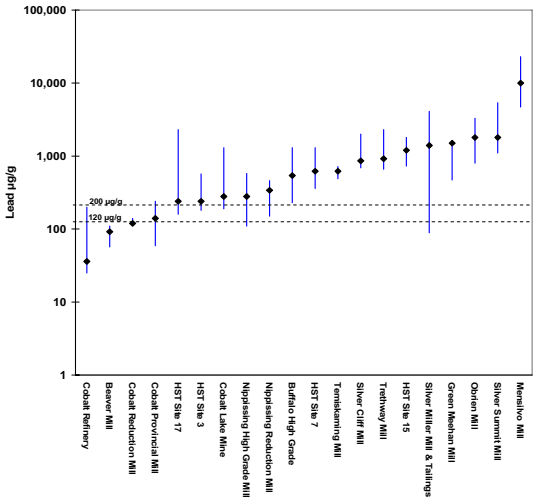


Figure 5.3.3: Mills, median [Pb].

and there was always a mix of the typical grey coloured and less typical rust coloured waste rock at these sites. The highest lead concentration in waste rockwas found at the Colonial Mine, which had a lead concentration of 20,000 µg/g.

There was also a wide range in the median concentrations of lead found at the mill sites; however, the overall range was higher than those found at the mine sites. Only four of the twenty mill sites had median lead concentrations below the *Table 2 Generic Standard*. Of the sixteen mills over the *Table 2 Generic* lead standard, fifteen ranged from 240 to 1,800 µg/g. The median lead concentrations at the Mensilvo Mill site were 20,000 µg/g with one location reporting a high concentration of 65,000 µg/g.

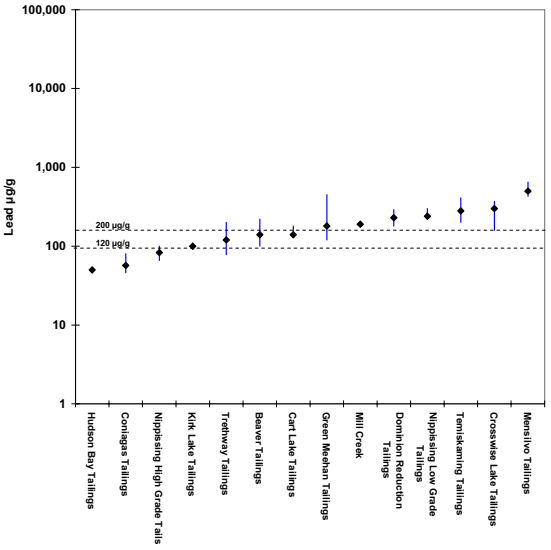


Figure 5.3.4: Tailings, median [Pb].

There was a very small range in median lead concentrations found in the tailing sites in comparison to the mine and mill locations. The median lead concentrations found at the tailings areas ranged from 50 to 1,000 µg/g with nine of the fourteen tailings sites having median lead concentrations below the *Table 2 Generic Standard*.

5.4 Mercury

Mercury in the Cobalt-Coleman Mining Camp is similar to antimony and lead in that mercury contamination is more site spec ific than arsenic. The source of mercury contamination however is different from the source of antimony and lead contamination. The source of the antimony and lead contamination in the Cobalt area is the ore that was mined. The majority of the mercury contamination was a result of the mercury that was used to refine the silver. The concentration

of mercury found naturally occurring in soil is very low. The current *O. Reg. 153-04 Table 1 Background* soil standard for mercury is 0.23 µg/g. The current *O. Reg. 153-04 Table 2 Generic* soil standard for mercury is 10 µg/g. The generic mercury standard is based on human health effects.

The fifty-eight discreet locations sampled in the Cobalt-Coleman Mining Camp have been ranked based on the median mercury concentrations and are presented in Figure 5.4.1 below. The median concentration and the 25th and 75th percentile values (blue bars) are also presented.

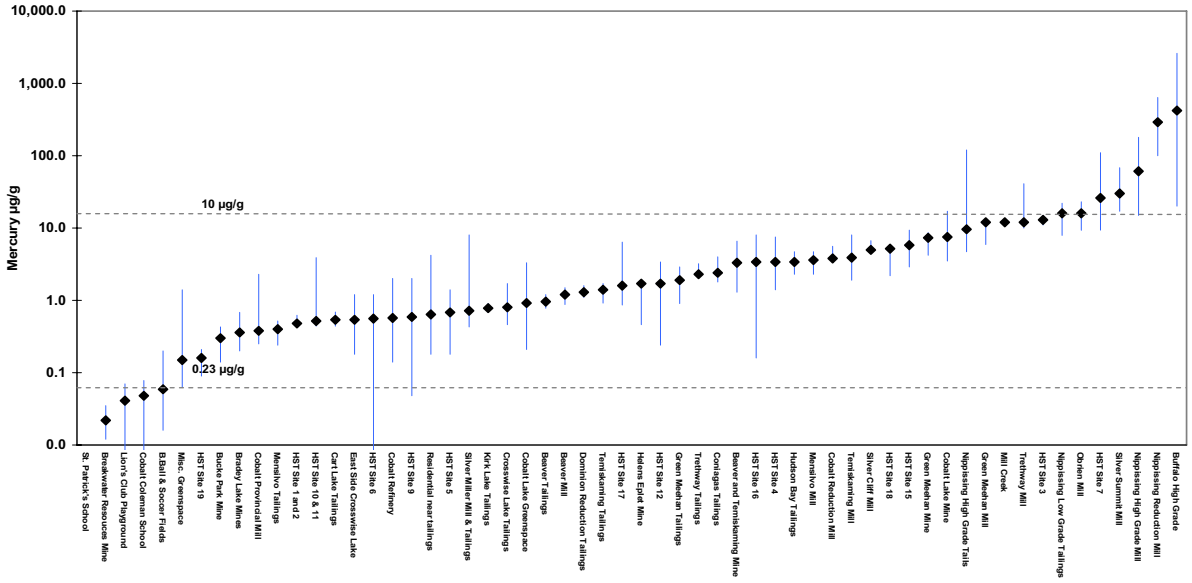


Figure 5.4.1: 58 locations ranked by median mercury concentrations (µg/g), with 25th and 75th percentile bars.

Only two of the fifty-eight sampling locations had median mercury concentrations below the *Table 1 Background Standard* of 0.23 µg/g. Forty-nine of the fifty-eight sampling locations had median mercury concentrations above the *Table 1 Background Standards* but below the *Table 2 Generic Standards* indicating widespread, low level mercury contamination in the Cobalt-Coleman Mining Camp. Of the seven sampling locations with median mercury concentrations above the *Table 2 Generic Standards*, the Buffalo High Grade Mill, the Nipissing Reduction Mill loading area, and the Nipissing High Grade Mill were by far the most mercury contaminated sites.

As expected, the mining locations had the highest concentrations of mercury. The mining locations have been categorized into mines, mills and tailings sites and then ranked according to median mercury concentrations (refer to Figures 5.4.2 to 5.4.4).

None of the median mercury concentration at the mine sites exceeded the Table 2 Generic Standard for mercury, however all but one mining location exceeded the *Table 1 Background Standard*. This is consistent with reports of trace amounts of mercury being found in the ore bodies in the Cobalt-Coleman Mining Camp area.

Median mercury concentrations at the twenty mill sites were significantly higher than those found at the mine sites. Only five mill sites had median mercury concentrations below the Table 2 Generic standard for mercury. The highest mercury concentrations were found at the Buffalo High Grade Mill, the Nipissing Reduction Mill and the Nipissing High Grade Mill. The highest concentrations occurred in locations where the mercury amalgamation process was used in the

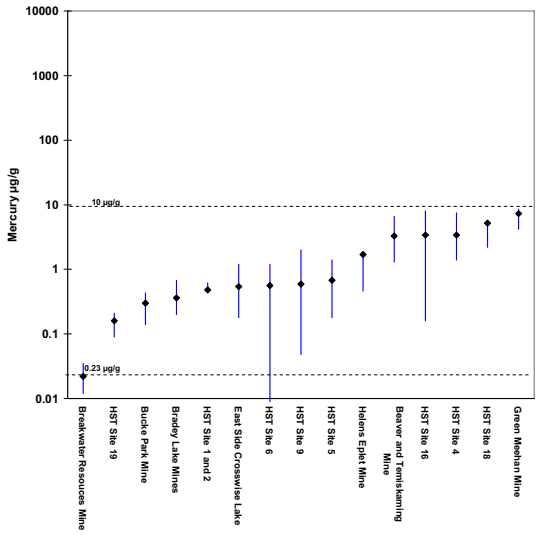


Figure 5.4.2: Mines, median [Hg].

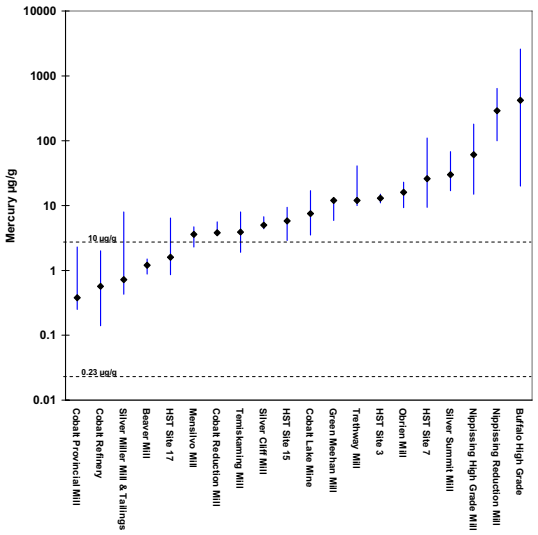


Figure 5.4.3: Mills, median [Hg].

extraction and refining of the silver.

Mercury concentrations in the tailings were similar to those found at the mine sites. Only two of the fourteen tailing sites had median mercury concentrations that exceeded the Table 2 Generic standard for mercury. These were the Nipissing Low Grade tailings and the Mill Creek tailings, which originated from the Nipissing Low Grade tailings. Median mercury concentrations at the remaining tailings sites fell between the Table 1 Background and Table 2 Generic standards. The range of the median mercury concentrations at the tailings sites was small, as would be expected.

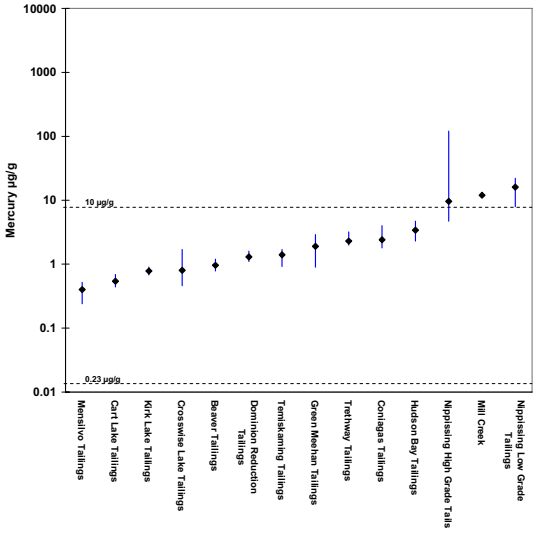


Figure 5.4.4: Tailings, median [Hg].

5.5 Vegetation

Only a handful of vegetation samples were collected during the course of the Ministry's Cobalt-Coleman soil assessment program. There were too few samples collected with no accompanying control samples to merit including the results in this report. The objective of sampling vegetation growing in the contaminated areas was to determine the levels of arsenic and metals that may be accumulating in vegetation and subsequently consumed by animals.

The effects of the historical mining activities on vegetation growth at the mine, mill, and tailing areas was clearly evident during the five years of soil sampling in the mining camp. Under normal circumstances, areas that had been disturbed to the degree found at the Cobalt-Coleman Mining Camp would have naturally revegetated during the time that has elapsed since these sites were abandoned. Some sites, such as the Nipissing High Grade Mill, the Nipissing Reduction loading area, and the Green Meehan Mine and Mill have been abandoned for eighty to ninety years and very little natural revegetation has occurred. Any revegetation that has occurred involves arsenic tolerant plant species.

There are two ways in which the materials, waste rock, mill waste and tailings, resulting from the mining activities have affected the revegetation of these areas. The first is the physical nature of the material. This applies mainly to the waste rock and the coarse grained tailings. Although there are numerous native colonizing species that can grow on barren, nutrient poor soils, and even rock outcrops, one of the requirements for growth is an adequate supply of moisture. In areas where coarse grained tailings or waste rock have been piled well above the natural water levels there is insufficient moisture to sustain plant growth as water drains out of these materials too quickly to support vegetation.

The Hudson Bay Tailings is an example of where a lack of moisture in the coarse grained tailings has inhibited revegetation. As noted previously, the coarse grained tailings generally had lower concentrations of arsenic and metals in comparison to the fine grained tailings. Arsenic concentrations in these tailings were usually below 1,000 µg/g, levels at which arsenic tolerant plants will grow. The median arsenic concentration in the Hudson Bay tailings were 540 µg/g, sufficiently low enough to allow natural revegetation to have occurred, however large areas of the tailings have not revegetated.

The other way in which the waste rock, mill waste and tailings have inhibited the natural revegetation process is through arsenic and metal toxicity. Arsenic is the most phytotoxic contaminant of all the contaminants associated with mining activities at Cobalt-Coleman. A number of patterns were observed over the five year sampling program. In areas where no vegetation was present there was either a lack of moisture or arsenic concentrations were above 2,500 µg/g. In areas where Baltic rush (Juncus balticus) was growing the arsenic concentrations were below 2,500 µg/g. Baltic rush, which is a wetland species, was only observed growing on mill wastes or tailings. It was never observed growing in uncontaminated wetland areas in the Cobalt-Coleman Mining Camp. This species was often observed growing in habitats where it would normally not be found, such as on the sides of hills that were well drained. In areas where the Baltic rush did grow, it was often the dominant species, effectively a monoculture, and over time had formed thick organic mats up to 8 cm thick over the tailings. The arsenic concentration range at which Baltic rush grew depended upon the drainage. For tailings that were predominately wet, it was found growing in areas with arsenic concentrations as low as 500 µg/g. For well drained areas, other less tolerant species were the dominant vegetations.

Two of these less dominant species that are tolerant to arsenic were the common horsetail (*Equisetum sp.*) and rough bentgrass (*Agrostis scabra* Willd.), also known as rough hair grass or tickle grass. Of these two species, the rough bentgrass was more tolerant than the horsetails. Horsetails were more often observed growing on the tailings, while the rough bent grass occurred more frequently at mill sites. Horsetails growing on contaminated sites were usually shorter and did not branch as horse tails growing on uncontaminated soil. Other plants that appeared to be somewhat tolerant to arsenic were goldenrod and a type of moss that was not identified.

It should be noted that all of the above is based on observations made while sampling the tailings, mill wastes and waste rock and that no systematic measurement or observations were made. A thorough study of the location and type of vegetation, its abundance and chemical properties should be made as part of any ecological risk assessment that may be done on the Cobalt-Coleman Mining Camp in the future.

6. Conclusions

The Ontario Ministry of the Environment's soil assessment program conducted between 2003 and 2007 in the Cobalt-Coleman Mining Camp is the most extensive investigation to date of the environmental impacts of past mining activities on the terrestrial ecosystem in the Cobalt area. Extensive areas of contamination with high concentrations of arsenic and other metals were found in the Cobalt-Coleman Mining Camp which is consistent with previous work that has been conducted in Cobalt-Coleman area. Many sites reported elevated concentrations of metals that were above the province's background and effects-based soil standards (Ontario Regulation 153). This contamination has directly affected the natural ecosystem in this area including significant impacts on vegetation. Other work conducted by the Ministry of the Environment has also shown significant impacts to the aquatic ecosystem (e.g., Awad et al, 2009). No systematic studies have been undertaken to determine the affects of this contamination on mammals or birds.

Arsenic is the major element of concern in the Cobalt-Coleman Mining Camp. Although concentrations of other elements such as antimony, cobalt, copper, lead, mercury, nickel, silver, and zinc are also very high, in most cases arsenic concentrations outweigh the possible affects of these other elements. It must be noted however that there are sites where these other metals are of high enough concentrations that they may outweigh the possible affects of arsenic and as such must not be overlooked.

The concentrations of arsenic found in the waste rock fines material, mill waste, and tailings are high enough to pose a possible risk to human health. A screening level risk assessment, conducted by the Ministry on the results of the soil sampling completed in 2003, showed a potential human health risk to tourists visiting the Historical Silver Trail sites for a period of one day (MOE, 2005). Visual observations made by the sampling crews during this investigation found evidence of regular human activity at the sites sampled even in remote, hard to access areas. These activities were more frequent the closer the site was to residential neighbourhoods and became less frequent with distance and difficulty of access. The only mining locations where there was no obvious sign of humans accessing the site on a regular basis were those locations that had been fenced off as physical mine hazards.

The results presented in this report will provide valuable information for any human or ecological risk assessments that may be conducted on the Cobalt-Coleman Mining Camp in the future.

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